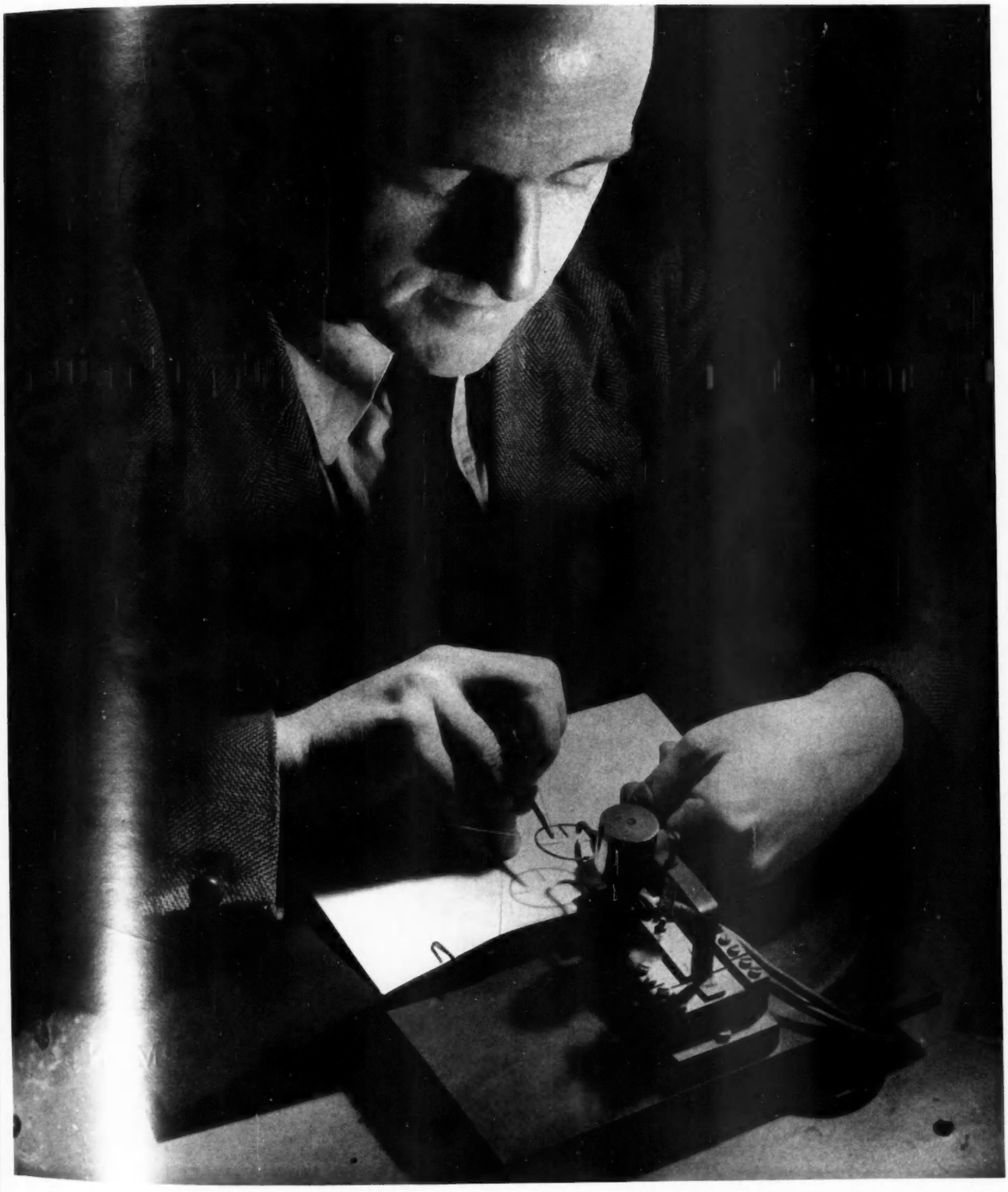
ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 181 No. 4707 *LONDON, FRIDAY, MAY* 25, 1956 PRICE 2s.



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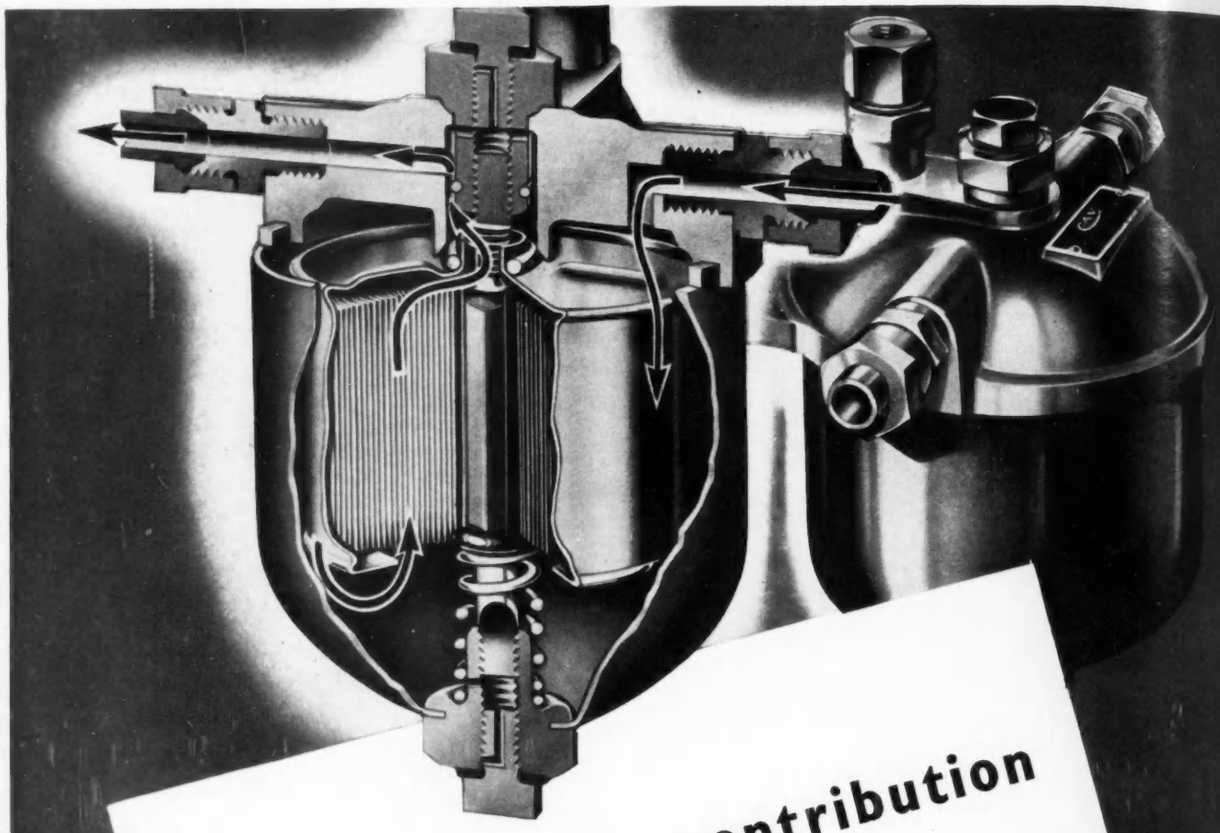

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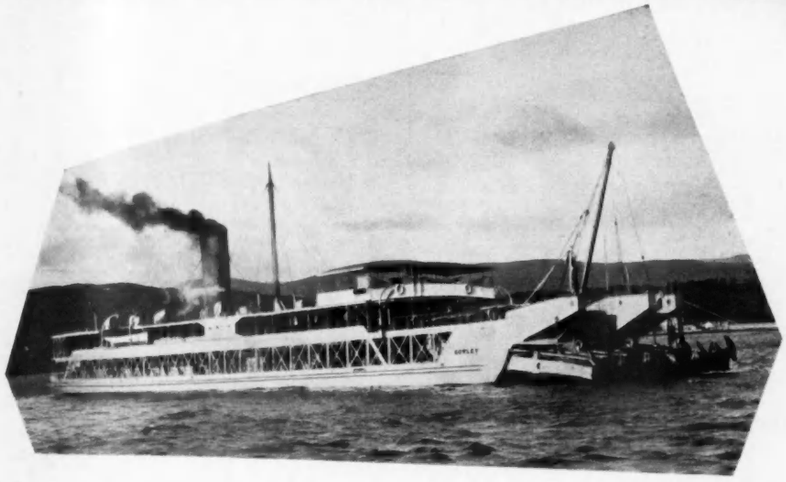

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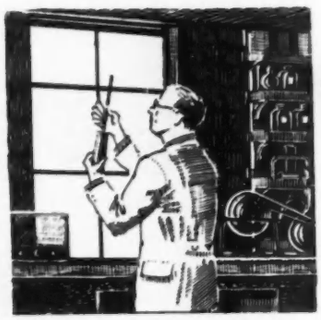

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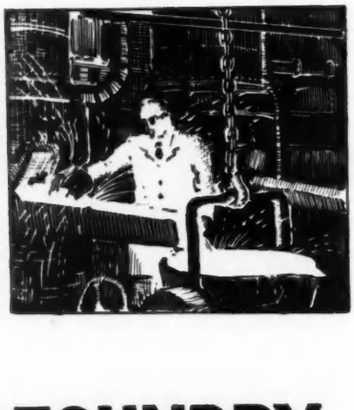

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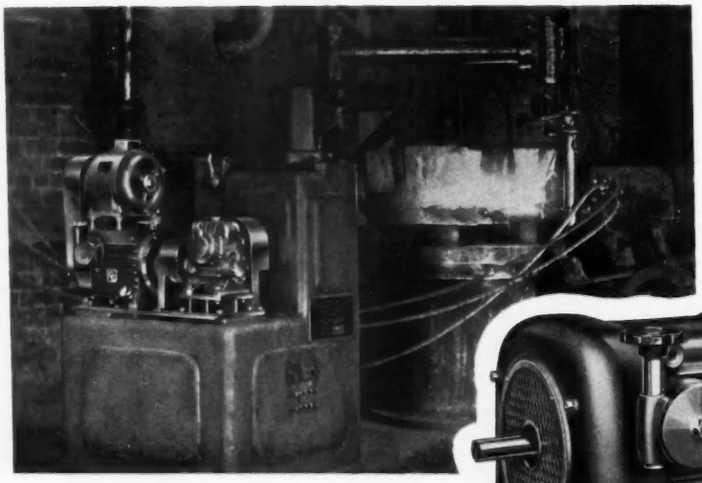

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Photograph by courtesy of Messrs. Crofts (Engineers) Ltd.

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INDEX TO ADVERTISEMENTS

	PAGE
Abelson & Co. (Engineers), Ltd.	15
Adamson, D., & Co., Ltd.	31
Adamson, Joseph, & Co., Ltd.	118
Air Control Installations, Ltd.	42
Alexander, G. H., Machinery, Ltd.	119
Allen, E. & Co., Ltd.	89
Allspeeds, Ltd.	32
Ames Crosta Mills & Co., Ltd.	114
Andre Rubber Co., Ltd.	87
Armstrong Patents Co., Ltd.	98
Armstrong Stevens & Son, Ltd.	116
Arpic Eng'g., Ltd.	44
Ashton, N. C., Ltd.	115
Atlas Copco Group of Companies *Wrapper*	VII
Austin, J., & Sons (Dewsbury), Ltd.	18
Austinlite, Ltd.	25
Automotive Products Co., Ltd.	9
Babcock & Wilcox, Ltd.	41
Bagnall, W. G. Ltd.	113
Bailey, Sir W. H., & Co., Ltd.	1
Baker Platinum Division	10
Barclay Kellett & Co., Ltd.	122
Beecham Buildings, Ltd.	53
Bell, H. (Machine Tools), Ltd.	128
Booth, James, & Co., Ltd.	48
Booth, Joseph, & Bros.	50
Braby, F., & Co., Ltd.	22
Braithwaite & Co. (Engineers), Ltd.	123
British Aluminium Co., Ltd.	34
British Ermeto Corp., Ltd.	20
British Insulated Callender's Cables, Ltd.	43
British Ropeway Eng'g. Co., Ltd.	114
British Steam Specialties, Ltd.	119
British Thermostat Co., Ltd.	104
British Thomson-Houston Co., Ltd.	35
British Twin Disc & Clarifiers, Ltd.	120
British Tyre & Rubber Co., Ltd.	120
Broadbent, R., & Son, Ltd.	116
Broom & Wade, Ltd.	40
Brown, Lenox & Co., Ltd.	57
Bryce Weir, Ltd.	119
Budenberg Gauge Co., Ltd.	24
Butterfield, W. P., Ltd.	6
Butterley Co., Ltd. *Wrapper*	V
C.A.V., Ltd. *Wrapper*	II
Cambridge Instrument Co., Ltd.	64
Carruthers, J. H., & Co., Ltd.	76
Carter, B. & F., & Co., Ltd.	120
Carter Gears, Ltd. *Wrapper*	IV
Celoform (Stockport), Ltd.	25
Chamberlain Industries, Ltd.	24
Chesterfield Tube Co., Ltd.	13
Churchill, Chas., & Co., Ltd. *Wrapper*	III
Clarke Chapman & Co., Ltd.	77
Climax Rock Drill & Eng'g. Works, Ltd.	88
Clyde Crane & Booth, Ltd.	50
Clyde Crane & Eng'g. Co.	50
Cohen, Geo., Sons & Co., Ltd.	51
Colvilles, Ltd.	26
Compoflex Co., Ltd.	61
Conveyor & Elevator Co. (1936), Ltd.	10
Cowans Sheldon & Co., Ltd.	112
Crane Packing, Ltd.	59
Craven Bros., (Manchester) Ltd.	121
Crockatt, W., & Sons, Ltd.	18
Croda, Ltd.	96
Crofts (Engineers), Ltd.	66
Dallow Lambert & Co., Ltd.	68
Darlington Forge, Ltd.	62
Davidson & Co., Ltd.	17
Dawson & Downie, Ltd.	118
Delta Metal Co., Ltd.	121
Distington Eng'g. Co., Ltd.	56
Dowty Nucleonics, Ltd.	17
Edwards, F. J., Ltd.	128
Electrothermal Eng'g. Ltd.	25
Evode, Ltd.	52
Farrar Boilerworks, Ltd.	100
Farington Steel Foundry of Leyland Motors, Ltd.	26
Fenner, J. H., & Co., Ltd.	95
Finlay Eng'g. Ltd.	19
Firth Brown Tools, Ltd.	125
Firth, Thos., & John Brown, Ltd.	49
Firth-Derihon Stampings, Ltd.	58
Fletcher Miller, Ltd.	7
Flexible Ducting, Ltd.	114
Fordsmith, H., Ltd.	11
Fowler, John, & Co., (Leeds) Ltd.	11 & 55
Fox, S., & Co., Ltd.	93
Fraser & Fraser, Ltd.	116
Galloway, Geo., & Co., Ltd.	120
Gas Council	28 & 29
General Electric Co., Ltd.	69
General Steel & Iron Co. Ltd.	98
Glikes, Gilbert & Gordon, Ltd.	101
Goodall, Clayton & Co., Ltd.	103
Goodyear Tyre & Rubber Co. (G.B.), Ltd.	64
Grafton Cranes, Ltd.	22
Great Eastern Oil Co., Ltd.	105
H.M. Stationery Office	117
Hadfields, Ltd.	47
Halesowen Steel Co., Ltd.	117
Hall, J. & E., Ltd.	70
Hallamshire Steel & File Co., Ltd.	103
Harland Eng'g. Co., Ltd.	107
Harvey, G. A., & Co. (London), Ltd.	46
Hayes Engineers (Leeds), Ltd.	99
Head, Wrightson Aluminium, Ltd.	106
Heap, Joshua, & Co., Ltd.	96
Heat Transfer, Ltd.	126
Heather Filters, Ltd.	110
Hick, Hargreaves & Co., Ltd.	24
Hillman, J. & A., Ltd.	9
Holland B.A. Eng'g. Co., Ltd.	121
Holmes, C. D., & Co., Ltd.	21
Hudswell, Clarke & Co., Ltd.	120
Hunt, R. & Co., Ltd.	126
Ilford, Ltd.	63
Imperial Chemical Industries, Ltd.	60 & 67
International Combustion Products, Ltd.	85
International Meehanite Metal Co., Ltd.	73
Keith Blackman, Ltd.	21
Kitchen & Wade, Ltd.	15
Klinger, Richard, Ltd.	75
Leeds Eng'g. & Hydraulic Co., Ltd.	122
Lees, H., & Co., Ltd.	79
Levy, B., & Co.	119
Lloyds (Burton), Ltd.	38
Luton Eng'g. Pattern Co.	122
McArs, Alex.	23
McCalls Macalloy, Ltd.	9
McGraw-Hill Publishing Co., Ltd.	3
Machinoexport	8
Marshall Fleming & Co., Ltd.	121
Measurement, Ltd.	71
Mechanical Equipments, Ltd.	5
Mechanical Handling Engineers' Assoc.	112
Mek-Elek Eng'g., Ltd.	117
Metafiltration Co., Ltd.	12
Metallic Valve Co., Ltd.	12
Metropolitan - Vickers Electrical Co., Ltd.	65
Modern Machine Tools, Ltd.	23
Morris, B. O., Ltd.	84
Moss Gear Co., Ltd. *Wrapper*	VIII
Mulberry Co.	127
National Gas & Oil Engine Co., Ltd.	36
Neill, J., & Co. (Sheffield), Ltd.	119
Newalls Insulation Co., Ltd.	14
Newbury Diesel Co., Ltd.	122
Norris Bros., Ltd.	127
Osborn, Samuel, & Co., Ltd.	111
Parmiter Hope & Sugden, Ltd.	78
Parsons, C. A., & Co., Ltd.	74
Pegler & Louden, Ltd.	5
Perkins, F., Ltd.	81
Phillips, J. W. & C. J., Ltd.	11
Pioneer Oilsealing & Moulding Co., Ltd.	122
Plowright Bros., Ltd.	109
Pool, J. & F., Ltd.	122
Positive Lock Washer Co., Ltd.	122
Power Plant Co., Ltd.	80
Pratchitt Bros., Ltd.	18
Proctor, Jas., Ltd.	117
Radiovisor Patent, Ltd.	14
Rawlplug Co., Ltd.	9
Raybestos-Belaco Ltd.	27
Reavell & Co., Ltd.	108
Renold Chains, Ltd.	27
Renshaw Foundry, Ltd. *Wrapper*	IV
Research Engineers, Ltd.	2
Reyrolle, A., & Co., Ltd.	83
Rice & Co. (Leeds), Ltd.	1
Robertson, W.H.A., & Co., Ltd.	90
Rocol, Ltd.	109
Rose Downs & Thompson, Ltd.	102
Rubert & Co., Ltd.	15
Russell, G., & Co., Ltd.	117
Ruston & Hornsby, Ltd.	54
St. George's Engineers, Ltd.	99
Sanderson Bros. & Newbould, Ltd.	122
Saunders Valve Co., Ltd.	110
Serck, H. O., Ltd.	125
Shaw, W., & Co., Ltd.	16
Simons, Wm., & Co., Ltd. *Wrapper*	94, 116, 124 & 128 III
Small & Parkes, Ltd.	115
Smith, J. (Keighley) Ltd.	91
Smith & McLean, Ltd.	115
Smiths Industrial Instruments, Ltd.	82
Soag Machine Tools, Ltd.	127 & 128
Spencer-Bonecourt Clarkson, Ltd.	100
Spirax-Sarco, Ltd.	113
Steel Co. of Wales, Ltd.	39
Steels Eng'g. Products, Ltd.	37
Stillite Products, Ltd.	101
Stothert & Pitt, Ltd.	106
Superheater Co., Ltd.	120
Taylor, F., & Sons (Manchester), Ltd.	102
Taylor & Challen, Ltd.	13
Taylor & Hubbard, Ltd.	117
Technoexport	30
Teddington Industrial Equipment, Ltd.	111
Temperature, Ltd.	11
Thew, Ed. H., Ltd.	118
Thompson, John (Dudley), Ltd.	86
Thompson, John Instrument Co., Ltd.	86
Twiflex Couplings, Ltd.	72
Unbrako Socket Screw Co., Ltd.	127
Uni-Gun Lubricating Equipment, Ltd.	88
Unicone Co., Ltd.	22
United States Metallic Packing Co., Ltd.	104
United Steel Companies, Ltd.	93
United Wire Works, Ltd.	111
Vokes, Ltd.	92
Vulcan Boiler & General Insurance Co., Ltd.	12
W.M.W.-Export	16
Wailes, Geo., & Co., Ltd.	118
Ward, Thos. W., Ltd.	94, 116, 124 & 128
Watson, H. T. Ltd.	17
Weir, G. & J., Ltd.	33
Wellman Bibby Co., Ltd.	16
Wellman Smith Owen Eng'g. Corpn., Ltd.	105
Weston, C., & Co., Ltd. *Wrapper*	VI
Wickman, Ltd.	45
Wigglesworth, F., & Co., Ltd.	10
Winn, W. Martin, Ltd.	107
Wiseman, A., & Co., Ltd.	19
Wood, Edw., & Co., Ltd.	97
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WATER ENGINEER, PUBLIC WORKS DEPARTMENT.

Appointment on contract/gratuity terms for three years in the first instance. Prospect of permanent appointment. Salary £1200 p.a. Substantial gratuity. Free Passages. Generous Home Leave. Low Income Tax.

Candidates should hold a University degree or diploma recognised as exempting from or have passed Final Parts I and II of the A.M.I.C.E. examination and have had experience in new water development projects.

Apply DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1. Give details of age, qualifications and experience Quote BCD.112/33/01/D5. L 692

CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION.

ASSISTANT MECHANICAL ENGINEERS.

CONSTRUCTION DEPARTMENT, DIVISIONAL H.Q.

Opportunities are available for applicants to gain knowledge and advancement in modern Power Station development with an experienced team in the Chief Generation Engineer's (Construction) Department, Divisional H.Q. Applicants should preferably have experience in design, layout and construction of mechanical plant in a Power Station or a thorough training in station operation and plant commissioning. Qualifications leading to Corporate Membership of the I.Mech.E. essential. Salary within range £850 10s.-£1085 p.a. including London Allowance. Superannuation Fund. N.J.B. conditions of service.

Applications, quoting vacancy number 56/378, and giving age and full details, should be forwarded to DIVISIONAL SECRETARY, CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION, P.O. BOX 136, GENERATION HOUSE, GREAT PORTLAND STREET, W.1, and be received within 14 days of this advertisement. L 697

HONG KONG PUBLIC WORKS DEPARTMENT.

ENGINEER,

TAI LAM CHUNG WATER SUPPLY SCHEME.

Appointment on contract/gratuity terms for three years in the first instance. Emoluments £1256-£2178 p.a. Free passages. Free Medical Attention. Generous Home Leave. Low Income Tax. Substantial gratuity payable on completion of contract.

Candidates should be Associate Members of the Institution of Civil Engineers preferably with a University Degree. Candidates who have not yet taken the Professional Interview I.C.E. can be considered for appointment at salary slightly less than the minimum.

Apply DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1. Give details of age, qualifications and experience. Quote BCD.112/51/01/D5. L 695

The BRITISH SOCIETY FOR RESEARCH IN AGRICULTURAL ENGINEERING has vacancies for

TWO ASSISTANT EXPERIMENTAL OFFICERS in the Horticultural Engineering Department, one to work on heating and ventilating problems, the other on cultivation machinery problems. Inter.B.Sc., H.N.C. or equivalent essential, and industrial or research experience in engineering or physics desirable. Salary scale £382 at age 20 rising to £706, with starting salary limited to £550 at age 26.

Application forms from SECRETARY, N.I.A.E., WREST PARK, SILSOE, BEDS. L 696

Applications are invited for the post of

PROFESSOR OF AIRCRAFT STRUCTURES at the AERONAUTICAL TECHNICAL INSTITUTE, SAO PAULO, BRAZIL. As Head of Division, will be responsible for teaching of aircraft structures and for research and extra-curricular courses; may also be asked to do consulting work by the Government. Should hold Ph.D. or M.Sc. and have industrial and/or research experience of the construction and experimental destruction of aircraft components. Some teaching experience essential. Duration up to 4 years, subject to renewal. Salary equivalent to £2640 p.a. plus allowances. Free furnished accommodation provided and 1st class return fares paid for appointee and dependants.—For further information and application forms write MINISTRY OF LABOUR AND NATIONAL SERVICE, ALMACK HOUSE, KING STREET, LONDON, S.W.1, quoting A12/BRA/127. L 698

CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION.

SENIOR ASSISTANT ENGINEER (MECHANICAL).

DIVISIONAL HEADQUARTERS.

Applications are invited for above position. Duties will be to act as senior assistant to the Mechanical Engineer in the Chief Generation Engineer's (C) Department, for design, specification and contract handling for all mechanical plant in new Power Stations and extensions. Candidates should have good technical qualifications, wide experience and preferably corporate membership of a major engineering institution. Salary and conditions in accordance with N.J.B. Agreement, Schedule B, Class AX/EX, Grade 1 = £1220-£1465 p.a.

Applicants who applied for vacancy number 56/294 will be considered and need not re-apply.

Applications, quoting vacancy number 56/384, may be made on form obtainable from DIVISIONAL SECRETARY, CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION, P.O. BOX 136, GENERATION HOUSE, GREAT PORTLAND STREET, W.1, and be received within 14 days of this advertisement. L 699

COMMONWEALTH OF AUSTRALIA.

SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY.

Applications are invited from qualified persons for the following position :—

EXECUTIVE ENGINEER GRADE 2.

£2273-£2713 p.a.

QUALIFICATIONS: Degree in engineering of a recognised University, Corporate Membership of a recognised Engineering Institution or equivalent professional qualifications acceptable to the Authority.

Specialised and extensive knowledge and experience in the organisation, supervision, and carrying out of all phases of the investigation, design, procurement and commissioning of large hydraulic gates and valves and the preparation of programmes, cost estimates, contract specifications and tender analyses for such work.

A thorough knowledge of administrative and commercial practices and procedures and the ability to organise professional engineering staff and to promote co-operation.

Location initially in the Gates and Valves Section, Cooma, N.S.W., or as required by the Authority. Housing, on a rental basis, available for a married appointee. Single accommodation in Staff Hostels.

Commencing salary will be determined by qualifications and experience.

Subject to certain conditions, first class steamship fares to Australia of the successful applicant, his wife and children under the age of 16 years, will be paid by the Authority.

Applications, in writing, with copies of testimonials, stating age, nationality, marital status, war service (if any), present position and salary, and giving full particulars of qualifications and experience, should be addressed to the CHIEF ADMINISTRATIVE OFFICER, P.O. BOX 332, COOMA NORTH 4S, N.S.W., AUSTRALIA. L 744

TECHNICIANS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE

for the direct supervision of industrial staff operating and maintaining electrical and mechanical plant including normal building services, heating and ventilating plant and associated equipment. Shift working and the wearing of protective clothing will be required as necessary. Applicants should have a recognised engineering apprenticeship or equivalent and have experience of switchgear operation.

Salary: £646 (at age 26 or over)-£786 per annum.

Contributory Superannuation Scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates; alternatively, assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to SENIOR RECRUITMENT OFFICER, at above address not later than 29th May, 1956, quoting reference 1162/26. L 683

THE UNIVERSITY OF MANCHESTER.

Applications are invited from graduates in Physics, Chemistry, Metallurgy, Biology or Engineering for the post of

ASSISTANT LECTURER IN DENTAL MATERIALS. The person appointed will be concerned with work on the physical properties of dental materials. There is a wide scope for research in this field and ample facilities are available. Salary on a scale £550 by £50 to £650 per annum with membership of F.S.S.U. and Children's Allowance Scheme.—Applications should be sent not later than June 30th, 1956, to the REGISTRAR, THE UNIVERSITY, MANCHESTER, 13, from whom further particulars and forms of application may be obtained. L 709

MINISTRY OF SUPPLY requires **WORKSHOP OFFICER** at Doncaster to supervise operations at central depot for repair of vehicles (including petrol and C.I. engines) by contractors; to apply acceptance standards, etc. Qualifications: Recognised engineering apprenticeship, preferably in motor industry. H.N.C. or equivalent desirable. Experience repair shop organisation and reconditioning processes essential, also ability to drive and test critically all types civil and military wheeled vehicles. Salary: Within £860-£1070 p.a.—Forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C396/6A. L 745

THE ROYAL TECHNICAL COLLEGE, GLASGOW.
(In Affiliation with The University.)

Applications are invited for **LECTURESHIP IN METALLURGY.** Candidates should have a good degree and preferably industrial experience. Salary on scale to £1350 with F.S.S.U. and Family Allowances.—Application forms from the Secretary. L 767

Applications are invited for the appointment of an **ENGINEERING ASSISTANT** in the Water Department of the Epsom and Ewell Corporation. Salary APT. III (£640-£765), plus London Weighting. Applicants should have passed or be studying for Part I of the Examination of the Institution of Civil Engineers and should have had experience in Waterworks Engineering.—Applications, giving details of age, qualifications, training and experience, together with copies of three testimonials, should be sent in an envelope endorsed "Engineering Assistant" to MR. L. D. EVANS, B.Sc., A.M.Inst.C.E., A.M.Inst.W.E., BOROUGH WATER ENGINEER AND MANAGER, WATERWORKS, EAST STREET, EPSOM, not later than Wednesday, the 13th June, 1956. L 720

OXFORDSHIRE EDUCATION COMMITTEE.

WEST OXFORDSHIRE TECHNICAL COLLEGE, WITNEY.

Principal: E. A. CHILCOTT, B.Sc.(Econ.).

Required for September or as soon as possible thereafter,

GRADE A ASSISTANT LECTURER in the Department of Engineering and Building. Applicants should have served an apprenticeship in a Machine Shop, Toolroom or General Engineering Shop. Minimum qualifications required: Ordinary National Certificate or Final City and Guilds Machine Shop Engineering Certificate. The successful applicant will be expected to teach Machine Shop Engineering subjects to Intermediate level, Engineering Drawing and/or Practical Mathematics to S.I. standard and Workshop Practice and Theory in the Secondary Technical Department. Ability to assist with Elementary Auto Work and/or Welding would be an additional qualification.—Application forms obtainable from the undersigned and should be returned to the Principal within fourteen days of the appearance of this advertisement.

A. R. CHORLTON,
Director of Education.

County Offices,
Oxford. L 763

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE.

Applications are invited from **CIVIL AND MECHANICAL ENGINEERS OR FROM PHYSICISTS** with experience in industry, for a post as Lecturer in Engineering. Starting salary according to qualifications and experience up to £950 per annum on a scale £650 by £50 to £1350 p.a. with Superannuation and Childrens Allowances.

Facilities are available for research.

Further particulars from the REGISTRAR, UNIVERSITY COLLEGE, CARDIFF, to whom application should be sent by June 8.

CATHAYS PARK,
CARDIFF. L 768

CITY COUNCIL OF SINGAPORE.

Applications are invited from qualified Civil Engineers for appointment as **RESIDENT ENGINEER** to supervise the construction of the new Ulu Pandan Sewage Treatment Works for the City Council of Singapore under the direction of the City's Consulting Engineers, Messrs. J. D. & D. M. Watson. The work includes the construction of sewage pumping stations and rising mains, and activated sludge disposal works, with power generation from sludge gas.

Applicants should be between 38 and 50 years of age, and should be Corporate Members of the Institution of Civil Engineers. They should have extensive practical experience of civil engineering construction preferably connected with sewer construction, pumping stations and sewage purification plants.

The salary inclusive of cost of living allowances will be 3000 dollars per month (equivalent to £4200 per annum). The appointment will be for two periods of two years each, and four weeks paid leave per year of resident service will be granted at the end of each period. Free return passages will be provided including family (subject to certain limits) and quarters with hard furnishings will be available at reasonable rental.

Applications in DUPLICATE stating age, qualifications and experience, with the names of at least two referees should reach the COUNCIL'S CONSULTING ENGINEERS, MESSRS. J. D. & D. M. WATSON, MM.I.C.E., 18, QUEEN ANNE'S GATE, WESTMINSTER, S.W.1, not later than Thursday, 7th June, 1956. L 761

LIVERPOOL REGIONAL HOSPITAL BOARD
(Repeat Advertisement.)

Applications invited from suitably qualified persons for permanent superannuable post of **DEPUTY REGIONAL ENGINEER,** Regional Engineer's Department, 2, Union Street, Liverpool 3.

Candidates must be Corporate Members of the Institution of Civil Engineers or Mechanical Engineers or Electrical Engineers or Structural Engineers and must have had wide experience in engineering design and operations preferably in connection with hospitals and institutions.

The person appointed will be required to deputise for the Regional Engineer over the whole engineering field and undertake under his direction the design and supervision of engineering projects and preparation of technical reports.

Salary £1195 by £50(4) by £30(1)-£1425. The appointment will be terminable by three calendar months' notice.

Applications stating age, qualifications, experience, present and previous appointments together with names and addresses of three referees (two technical) to reach me at 19, JAMES STREET, LIVERPOOL, 2, by 4th JUNE, 1956.

VINCENT COLLINGE,
Secretary to the Board. L 760

DERBY AND DISTRICT
COLLEGE OF TECHNOLOGY.

Principal: T. HEAP, Ph.D., M.Sc., F.R.I.C., A.M.I.I.A.

Applications are invited for the post of **ASSISTANT GRADE B** in the Mechanical Engineering Department, with special reference to Applied Mechanics and Heat Engines. Some knowledge of Production Engineering would be an additional recommendation. Duties to commence on 1st September, 1956.

Candidates should hold a degree or equivalent qualification and have had good industrial experience.

Salary in accordance with the Burnham Scales for Teachers in Establishments for Further Education—Assistant Grade B: £525 p.a. by £25 to £820 plus allowances for degree and training and up to 12 increments of £18 each for approved industrial experience.

Application forms and further particulars may be obtained from the PRINCIPAL, DERBY AND DISTRICT COLLEGE OF TECHNOLOGY, NORMANTON ROAD, DERBY, by whom completed applications should be received within two weeks of the appearance of this advertisement. L 743

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

requires an

ENGINEER, to be responsible for the organisation and control of workshops engaged in manufacture of scientific instruments and apparatus.

Applicants should have served a recognised engineering apprenticeship, or have had equivalent training, and be corporate members of the Institution of Mechanical Engineers or have exempting qualifications. A sound knowledge of machine tools and a wide experience in workshop techniques and production methods is essential.

Salary: Engineer II—£1199-£1504 per annum.

Contributory pension scheme; five-day week; excellent working conditions and generous leave allowances.

Married officers living outside the Establishment's transport area will be eligible for housing under Authority arrangements or, alternatively, substantial assistance towards legal expenses incurred in house purchase will be available.

Send POSTCARD for application forms, which must be returned by 5th June 1956, to ESTABLISHMENT OFFICER, A.E.R.E., HARWELL, DIDCOT, BERKS., quoting reference 555/26. L 686

WOOLWICH POLYTECHNIC, LONDON, S.E.18.

Principal: J. S. TAIT, Ph.D., B.Sc., A.R.T.C., M.I.E.E., M.I.Mech.E.

Applications are invited for:—

LECTURER IN MECHANICAL ENGINEERING SUBJECTS. Candidates should have a good Honours Degree with some practical experience and be competent to take a selected subject or subjects up to Final Degree standard.

ASSISTANT GRADE B FOR MECHANICAL ENGINEERING SUBJECTS. Candidates should have a Higher National Certificate or similar qualification and industrial experience, preferably in Motor Vehicle Engineering.

Salary Scale: Lecturer £965-£25-£1065, plus London Allowance of £36-£48. Grade B £621-£958 starting salary according to qualifications and experience. (Revised scales under consideration.)—Particulars and application form from CLERK TO GOVERNORS, to be returned by 9th June, 1956. L 762

TYNE IMPROVEMENT COMMISSION.

APPOINTMENT OF CIVIL ENGINEERING ASSISTANTS.

Applications are invited from University Graduates in Engineering or Student Members of the Institution of Civil Engineers who have passed Parts I and II of the Associate Membership Examination for appointments as Engineering Assistants.

Applicants should preferably have experience of engineering work associated with a Dock and Harbour Authority, including the construction and maintenance of quays, cargo handling appliances, railways and buildings, surveying, water supply and drainage works and experience in the preparation of designs, estimates and contract drawings and specifications in connection therewith will be of advantage.

Successful applicants will be required to undergo a medical examination and to become members of the Tyne Commission Superannuation Fund.

Commencing salaries will be fixed according to qualifications and experience.

Applications stating age, education and training, qualifications and experience, and accompanied by two recent testimonials should reach the undersigned not later than 18th June, 1956.

R. N. EGGLETON,
Secretary.

Tyne Improvement Commission,
Bewick Street,
NEWCASTLE-UPON-TYNE, 1.
14th May, 1956. L 717

ELECTRICAL ENGINEER is required by the Industrial Group of the UNITED KINGDOM ATOMIC ENERGY AUTHORITY at DOUNREAY WORKS, THURSO, CAITHNESS, SCOTLAND.

DUTIES: To supervise the maintenance of H.T. and L.T. distribution equipment. Initial duties may be connected with the construction and takeover of electrical plant.

QUALIFICATIONS AND EXPERIENCE: Applicants must have served a recognised Electrical apprenticeship and be Corporate Members of the Institution of Electrical Engineers, or have equivalent qualifications. An honours degree in Engineering would be an advantage. Good electrical experience, preferably on the maintenance and operation of high rupturing capacity switchgear and associated protection gear is essential and power plant experience would be an advantage.

SALARY: £1199 rising by annual increments of approximately £40 to £1504 p.a.

The Authority's housing scheme at Thurso is progressing; alternatively, assistance may be granted towards legal expenses involved in house purchase. Hostel accommodation is available.

Successful candidate if under 55, will be required to join the Authority's Contributory Pension Scheme.

Suitably qualified persons are invited to send a POSTCARD quoting reference 1439 to the RECRUITMENT OFFICER, U.K.A.E.A., I.G. H.Q., RISLEY, NR. WARRINGTON, LANCS. Closing date 8th June, 1956. L 718

SCHOOL OF ENGINEERING, WASHINGTON UNIVERSITY, ST. LOUIS, MISSOURI, U.S.A., has vacancies in the departments of engineering drawing and mechanical engineering for

INSTRUCTORS AND ASSISTANT PROFESSORS

as either permanent or temporary appointments to teach in the following areas: engineering drawing, machine design, heat power engines, heat transfer and fluid mechanics. Men with university degrees are invited to submit their qualifications, education, and experience. Successful candidates may elect to pursue work towards advanced degrees.—Applications should be submitted to PROFESSOR H. E. GRANT, WASHINGTON UNIVERSITY, ST. LOUIS 5, MO., U.S.A. L 689

McGraw-Hill

Series in Mechanical Engineering

This new series, edited by R. G. Folsom, Director of the Engineering Research Institute at the University of Michigan, places a strong emphasis on the fundamental sciences behind engineering. It will provide textbooks for university and technical college, as well as monographs and reference books for the research worker and professional engineer. New material such as Mass Transfer and Nuclear Power Plants will be added to the usual range of subjects.

to be published shortly

MACHINE DESIGN

JOSEPH E. SHIGLEY

A progressive textbook for mechanical engineering courses in Machine Design. It differs from earlier books in stressing the creative nature of design and teaching the student to think for himself. A representative selection of machine elements are examined in detail.

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MECHANISM

J. S. BEGGS

A thorough modern treatment for the advanced student and the practising design engineer, with many examples taken from industry.

49s

DYNAMICS OF MACHINERY

J. G. HARTMAN

Teaches techniques in the design and control of modern high speed machinery which are not covered in an elementary mechanics course.

56s 9d

McGraw-Hill

Classified Advertisements continued on Page 4

SENIOR SCIENTIFIC OFFICERS : SCIENTIFIC OFFICERS.

THE CIVIL SERVICE COMMISSIONERS invite applications for pensionable appointments. Interview Boards will sit at frequent intervals. The Scientific posts cover a wide range of scientific research and development in most of the major fields of fundamental and applied science. In biological subjects the number of vacancies is small: individual vacancies exist for candidates who have special knowledge of, or who are interested in palaeobotany, malacology, helminthology, acarology, foraminifera.

Candidates must have obtained a university degree with first or second class honours in an appropriate scientific subject (including engineering) or in Mathematics, or an equivalent qualification; or possess high professional attainments. Candidates for Senior Scientific Officer posts must in addition have had at least three years' post-graduate or other approved experience.

Candidates taking their degrees in 1956 may apply before the result of their degree examination is known.

Age Limits: Senior Scientific Officers, between 26 and 31, but specially suitable candidates under 26 may be admitted; for Scientific Officers, between 21 and 28 during 1956 (up to 31 for permanent members of the Experimental Officer class). Salary (London) Senior Scientific Officers: (men) £1135-£1310; (women) £999-£1220. Scientific Officers: (men) £539-£973; (women) £539-£898. Women's scales being improved under equal pay scheme. Somewhat lower rates in the provinces. Pay and conditions of service are under review.

Further particulars, for which early application is advised, from CIVIL SERVICE COMMISSION, SCIENTIFIC BRANCH, 30, OLD BURLINGTON STREET, LONDON, W.1, quoting No. S.53/56 for Senior Scientific Officers and S.52/56 for Scientific Officers. Applications for posts in any branch of Chemistry or Biology must be made by 30th June, 1956. L 710

WORKSHOP TECHNICIAN for Physics Department (radio-isotopes). Applicants should have served an Engineering Apprenticeship or hold O.N.C. Design experience an advantage. Salary scale £485-£555 plus £20/£30 London Weighting allowance.—Detailed applications to SECRETARY, HAMMERSMITH HOSPITAL, DU CANE ROAD, W.12. L 724

CENTRAL ELECTRICITY AUTHORITY HEADQUARTERS, S.E.1, require a **SENIOR ASSISTANT ENGINEER** (Feed Heating Plant). Duties will consist of investigations into feed heating plant design problems including the effect of cycle conditions on performance. The preparation of specifications and the critical assessment of the technical features and performance of designs as tendered. Candidates should preferably be C.M.I.Mech.E., and possess a sound knowledge of thermodynamics and have had recent experience in the Design Department of a manufacturer of feed heating plant for central power stations. Salary within £1225-£1575 p.a.—Application forms from D. MOFFAT, DIRECTOR OF ESTABLISHMENTS, WINSLEY STREET, W.1, to be completed and returned by 8th June, 1956. Quote Ref.: ENG/827. L 726

CENTRAL ELECTRICITY AUTHORITY, HEADQUARTERS, S.E.1, require a **SENIOR ASSISTANT ENGINEER (BOILER PLANT)** to conduct investigations into the economic and design aspect of large future boiler plant installations for high pressures and temperatures and their major auxiliary equipment, with particular respect to combustion, stress and chemical engineering considerations. Candidates should preferably be corporate members of the I.Mech.E. or I.Chem.E., and have experience in the manufacture or design of boilers or chemical plant. Salary £1225-£1575 p.a. —Applications to D. MOFFAT, DIRECTOR OF ESTABLISHMENTS, WINSLEY STREET, W.1, by 8th June, 1956. Quote Ref. ENG/824. L 727

MECHANICAL ENGINEER.

A young man about 30 years of age is required to work as an industrial engineering supervisor (in Outer London Area); must have served an indentured apprenticeship and had some years practical experience; a knowledge of Automatic Packing and Weighing Machinery and Electronics would be an advantage.

Technical Training up to B.Sc. (Engineering) or Higher National Certificate standard.

Commencing Salary £950 to £1200 according to qualifications and experience; pension scheme and sports club facilities.

Write giving full details of education, practical and technical training to BOX L 660, Offices of ENGINEERING.

PLANNING ENGINEER required, experienced in Estimating, Planning and Ratefixing for medium size Production Machine Shop. Excellent Pension Scheme operated. State experience, age and salary required to—PERSONNEL MANAGER, KENT ALLOYS, LIMITED, STROOD, ROCHESTER, KENT. L 592

EXPERIENCED CIVIL ENGINEER required to take charge and build up a new branch of an old-established consulting firm. Degree qualifications are necessary and experience of layout, design, and construction of all types of factories, warehouses, wharves, and industrial buildings and installations generally. The starting salary is on the scale £1500 to £2000 per annum, plus annual bonus and pension, and there are excellent prospects for the future. Age 35 to 45. Please reply with full particulars to BOX L 593, Offices of ENGINEERING.

GOOD JOBS for **ENGINEERS AND DRAUGHTSMEN** preferably with steelworks; experience but not essential.

Also opening for

RETIRING OR RETIRED ENGINEERS OR MANAGERS with Coke Oven or Blast Furnace or Steel Plant or Rolling Mill experience. For London office and elsewhere. Full discretion promised.—BOX L 607, Offices of ENGINEERING.

STRUCTURAL ENGINEER with wide experience of the design and detailing of all types of steel structures and with administrative experience required to act as deputy to the Chief Engineer by large firm of London Consultants. The firm is expanding and the vacancy offers excellent opportunities for the right type of man.—Write in confidence giving details of previous experience and salary required to BOX No. 355, GLOVERS ADVERTISING LTD., 351, OXFORD STREET, LONDON, W.1. G 635

APPOINTMENTS OPEN

A Company of Civil Engineering Contractors, specialising in Cement Gun and Pressure Grouting work, have vacancy for **YOUNG ENGINEER** in their London Office. Progressive and permanent position with pension scheme after probationary period. Duties include Site visits for supervisory and tendering purposes, preparing estimates and generally assisting on Contracts side of Company's business.

Applicants should state age, experience and give some idea of salary required to—THE CONCRETE PROOFING COMPANY, LIMITED, 96, VICTORIA STREET, LONDON, S.W.1. L 580

Forensic Engineers invite application from **ENGINEERING GRADUATES** with good background and industrial experience for responsible and individualistic post. Age preferably 28 to 33 years.—BOX L 610, Offices of ENGINEERING.

SENIOR DRAUGHTSMAN required by firm of world repute manufacturing tractors and farm machinery. Applicant should be capable of controlling the design and development of modifications and new agricultural machinery.

Previous technical and practical experience in this class of engineering a necessary qualification.

Salary commensurate with qualifications but applicant should state present salary.—BOX L 658, Office of ENGINEERING.

MECHANICAL ENGINEERING DRAUGHTSMAN, preferably holding Higher National Certificate or equivalent, experienced in textile dyeing and finishing machinery. Applications stating age, experience, qualifications, and salary required should be addressed to THE BRADFORD DYERS' ASSOCIATION, LTD., ENGINEERING DEPARTMENT, 39, WELL STREET, BRADFORD, 1. L 611

WILTON ICI WORKS

ENGINEERING DESIGNERS

The construction of the Company's factory at Wilton on a 2000-acre site has proceeded continuously since 1946 and now over ten million pounds are spent each year on new works. Staff with experience in design of modern works are required for this development.

The immediate vacancies are in the Design Office for :—

ASSISTANT TECHNICAL OFFICERS
MECHANICAL ELECTRICAL
CIVIL STRUCTURAL
INSTRUMENT

The appointments are to permanent staff and the Company is anxious to engage men who have had first rate experience to assist with the long-term plans for further development. Candidates in this category will be invited to interview, without commitment, at the Company's expense.

SALARIES
Commencing salaries up to £900 per annum will depend on the age and experience of candidates. The salaries of men engaged will be reviewed annually.

TERMS OF EMPLOYMENT
Five-day, 39-hour working week, Pension Fund, Profit Sharing Scheme, etc.

HOUSING
After joining the staff married men will receive a reasonable refund of removal (including travel) expenses, and to assist them in house purchase, facilities are available in approved cases for substantial loans; in addition, legal charges will be advanced.

Assistance is given in the procuring of rented houses, flats or lodgings.

Wilton is situated at the foot of the Cleveland Hills in Yorkshire, five miles from the coast. Working conditions are good and recreation facilities, including golf, tennis and badminton, are available.

Write for application form to: Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting advertisement reference ICI/X/302/e. L 541

VICKERS-ARMSTRONGS LIMITED,
VICKERS HOUSE, BROADWAY,
WESTMINSTER, LONDON, S.W.1.

Are being made the main contractors by the Admiralty for the first set of machinery for marine propulsion utilising nuclear energy.

They are seeking technical staff, as under, for work at Harwell:—

PHYSICISTS

Experimental Physicists with Honours Degrees in Classical Physics.

Experimental Physicists holding H.N.C. or G.C.E.

ENGINEERS

Men holding Honours or Pass Degrees in Mechanical Engineering with some experience in industry. In addition there are vacancies for assistants holding H.N.C. in Mechanical Engineering and who have served an apprenticeship.

DESIGNERS

Men having design experience, and holding Honours or Pass Degrees in Mechanical Engineering, and having practical experience, preferably in Marine Engineering, or on the technical side for the generation of power for use on land.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes.

Applications, giving full details, should be sent to the above address. L 524

APPLICATIONS ARE INVITED for the following appointments at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.

STRUCTURAL DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent). Candidates should be capable of accepting responsibility for complete projects.

MECHANICAL DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent, but consideration also given to candidates who have not yet completed their studies).

Experience should preferably (but not essentially) include equipment such as cranes, hoisting machinery (steam, diesel, electric) mechanical handling equipment, contractors' plant.

THESE ARE PROGRESSIVE PERMANENT POSITIONS IN AN EXPANDING ORGANISATION. The Company operates a contributory pension scheme and good Canteen facilities exist. Present Holiday arrangements respected. Salary in accordance with age, qualifications and experience. The Works are situated 15 minutes' bus ride from the centre of Ipswich. Applications to Works Manager at the above address. L 602

Interesting opening occurs for a **DRAUGHTSMAN WITH HIGHER NATIONAL CERTIFICATE** in Mechanical Engineering for varied work on plant layout and development. Good opportunities for advancement. Salary in accordance with experience.—Applications to PERSONNEL MANAGER, TURBO, LTD., KIRBY MUXLOE, NR. LEICESTER. L 605

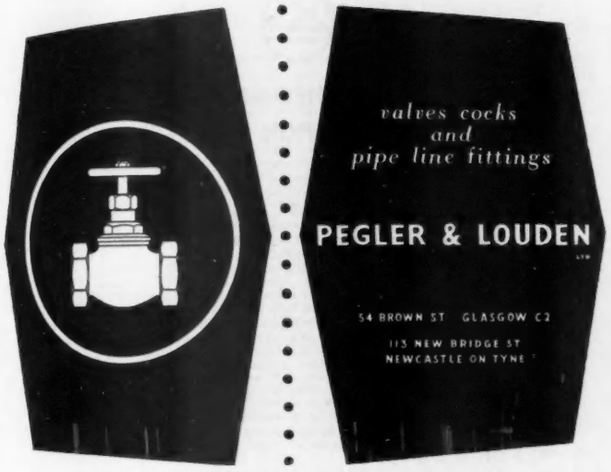
DRAUGHTSMAN required for Engine Design Schemes on small high-speed diesels must have initiative and experience. Good salary. Pleasant working conditions. Pension Scheme.—Apply CHIEF PERSONNEL OFFICER, PETTERS LIMITED, CAUSEWAY WORKS, STAINES. G 610

DRAUGHTSMAN—age about 30—National Certificate standard, general mechanical engineering and some electrical experience, including factory plant layout and services, structural knowledge an advantage. Also Junior Draughtsman—age 22/23—of good education with some experience of years—of general mechanical engineering. Five-day week. Contributory Pension Scheme.—Write, giving details of experience and stating salary required, to THE NESTLE COMPANY, LIMITED, HAYES, MIDDLESEX, quoting reference CGC/VS. L 567

BRITISH PETROLEUM COMPANY, LIMITED, offers

STUDENT APPRENTICESHIPS in Instrument Engineering, Chemical Engineering and Chemistry, which provide training for young men and lead to full professional qualifications. Age 18-19. Minimum qualifications required for Instrument Engineering: a good G.C.E. with "A" level Mathematics and Physics. For Chemical Engineering and Chemistry Apprenticeships: "A" level Mathematics, Physics and Chemistry are required. Apprentices will attend a Technical College for full-time study for six months of every year. The other six months are spent in a Refinery undergoing practical training. The duration of the apprenticeships is four years.—Written applications giving details of education and experience should be addressed to BOX 8931, c/o 191, GRESHAM HOUSE, E.C.2. L 739

RESEARCH SCIENTIST required for interesting new developments in domestic heating. Candidates should have a degree or equivalent in Physics. Previous research experience is not necessary, but applicants must have an aptitude for original work and the ability to apply a scientific training to practical objectives. The work is concerned with recent developments, and offers opportunities for training and experience in modern research techniques and instrumentation in exceptionally well-equipped laboratories. The post also offers opportunities for publishing the results of successful research and good prospects of advancement for graduates with research ability. Starting salary in range £600-£900. Five-day week. Superannuation and Grading Schemes.—Apply in writing to ASSISTANT SECRETARY, REF. C.35, B.C.U.R.A., RANDALLS ROAD, LEATHERHEAD. L 732



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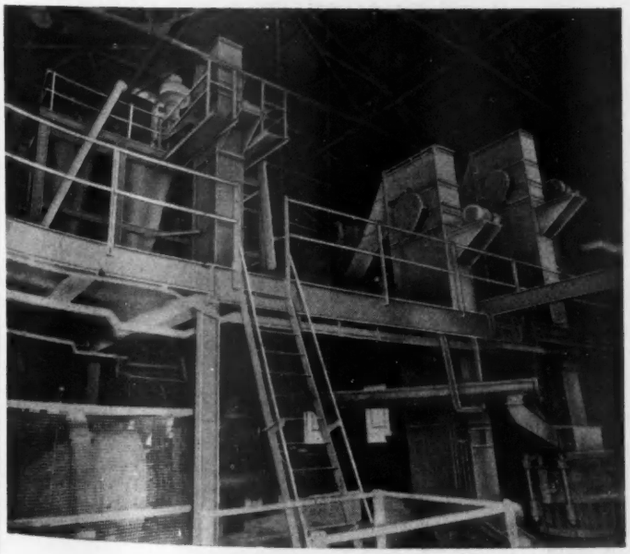

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G.E.C. STANMORE LABORATORIES

require a

CHIEF INSPECTOR

for the Engineering Development Group for work on Guided Weapon and Radar Projects.

Applicants should have had responsible experience of inspection in the Electronics industry both on the production line and at the stage of final test, and be well versed in A.I.D. procedure. A good knowledge of precision mechanical and electrical equipment, including microwave components, is essential. Familiarity with metallurgical, metal finishing and resin casting processes would be of particular advantage. Apply in writing, giving full details of education, qualifications and experience to the

STAFF MANAGER, THE GROVE, STANMORE COMMON, MIDDLESEX, QUOTING REF. E/JEM. L 756

QUALIFIED ENGINEER with Commercial experience required by Exporters for their expanding engineering business. Must be able to negotiate technically and commercially. Good salary and prospects. West End offices.—Please apply BOX L 687, Offices of ENGINEERING.

ASSISTANT ELECTRICAL ENGINEER required for extensive developments at a large Iron and Steel Works in the Midlands. H.N.C. or degree qualification in electrical engineering, with experience in heavy industry desirable but not essential. Housing prospects favourable.—Applicants should give details of experience and of salary required.—Apply to BOX L 705, Offices of ENGINEERING.

SERVICES ENGINEER. B.X. PLASTICS, LTD., BRANTHAM WORKS, NR. MANNINGTREE, ESSEX, require a Services Engineer with wide experience for the Brantham factory. Applications are invited from men with good experience in power generation, steam and electrical distribution, building work, and hydraulics. Candidates should hold a degree or possess equivalent qualifications. Age between 30 and 35. Salary by arrangement.—Applications which will be treated in confidence should give previous experience and qualifications, and be addressed to the PERSONNEL MANAGER at Brantham Works. L 746

BLAW KNOX LIMITED with expanding export business in Excavators and varied Construction Equipment have vacancies in their Watford Office for a few

DRAUGHTSMEN, preferably experienced in Mechanical and Constructional Design.—Write or 'Phone: PERSONNEL MANAGER, BLAW KNOX LIMITED, WATFORD.' (Telephone: Watford 9291.) L 741

LEADING MANAGEMENT CONSULTANTS with interests throughout the British Isles and Commonwealth requires the services of qualified and experienced

ENGINEERS AND ACCOUNTANTS.

Applicants willing to accept assignments for a limited initial period of three to five years in Canada, Africa or New Zealand are invited to apply. Age not over 40. Remuneration on a high scale with superannuation and expense allowances.—Full details of qualifications and experience to the PERSONNEL MANAGER, BOX L 736, Offices of ENGINEERING.

JUNIOR MECHANICAL ENGINEER required to train as Technical Representative attached to London Office of Gear Unit Manufacturers. Must have served full apprenticeship in Industrial Workshop and have Drawing Office experience. Age 22 to 26.—BOX L 614, Offices of ENGINEERING.

INSTRUMENT ENGINEER.

COURTAULDS LIMITED require an Instrument Engineer for their Central Instrument Department in Coventry. Applicants must be familiar with modern instrumentation theory and practice and be experienced in the handling of Instrumentation schemes for the automatic control of chemical processes, from the flow sheet stage to final commissioning.

Qualifications desired are a degree in a branch of engineering or physics, but applicants will be considered who have the required experience and alternative qualifications.

Candidates should write for a detailed form of application to the DIRECTOR OF PERSONNEL, COURTAULDS LIMITED, 16 St. Martins-le-Grand, London, E.C.1, quoting reference number B.35. L 466

SHELL REFINING & MARKETING CO., LTD.,

invite applications for the following vacancies in the Purchasing Department of their London office.

(A) **BUYER** with experience in large scale purchasing of heavy engineering plant and mechanical equipment, preferably with engineering knowledge or background. Candidates should not be over 40 years of age and with good educational standard.

(B) **ASSISTANT BUYER** to assist in purchasing engineering materials and equipment under supervision. Candidates should not be over 30 years of age with good educational standard essential.

These are career appointments with good prospects and pension rights. Salary according to age and experience.

Applications to STAFF DEPARTMENT, "SHELL" REFINING & MARKETING CO., LTD., SHELL COURT, WHITE KENNETT STREET, LONDON, E.1. L 519

DISTRIBUTION/UTILIZATION ENGINEER required for Natural Gas Undertaking in WEST PAKISTAN. Must be a well qualified Engineer with good gas distribution experience and prepared to undergo a short course of training in the United States in the specialised field of the Natural Gas Industry. Excellent salary and prospects, pension scheme, full furnished accommodation and medical attention. Only highly qualified men with ambition, initiative and personality should apply. Preferred age 32 to 35.—Write full personal details and particulars of qualifications and experience to BOX EG.249, c/o, 191, GRESHAM HOUSE, E.C.2. L 668

BILLINGHAM ICI DIVISION

Vacancies in

ENGINEERING RESEARCH DEPARTMENT

BILLINGHAM.

Applications are invited from Engineers, Physicists and Mathematicians for appointments as Technical Officers in the Engineering Research Department of the Billingham Division. The work will be of a specialist nature and candidates should preferably have already had experience on vibration. Current problems are connected with structural and foundation vibrations, pulsations in flowing fluids, torsional oscillations of crankshafts and aerodynamic noise. Publication of results of general interest is encouraged.

These appointments are permanent and pensionable and carry attractive salaries. There is also a profit-sharing scheme in operation. Assistance can be given towards house purchase and removal expenses in the case of married men.

Write, giving brief details of age, qualifications and experience to the Staff Manager, Imperial Chemical Industries Limited, Billingham Division, Billingham, Co. Durham, quoting reference M.5. L 749

Classified Advertisements continued on Page 6

VICKERS-ARMSTRONGS (ENGINEERS) LIMITED
BARROW-IN-FURNESS, LANCASHIRE

Are seeking technical staff, as under, for research and development work in connection with the application of new methods to the propulsion of ships.

ENGINEERS

Engineers holding Honours Degrees with experience in the field of marine or mechanical engineering.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes, and the production and installation of machinery.

TEST ENGINEER

For marine research work. A minimum standard of H.N.C. is required, and sea-going experience with Board of Trade Certificate will be a distinct advantage.

The above requirements offer a splendid opportunity to the right type of men, and good salaries will be paid in accordance with experience, ability and training.

The Barrow district is an extremely pleasant one in which to reside, offering the close proximity of sea, countryside and the Lake District. In suitable circumstances, housing accommodation may be available if required by successful applicants, and a contributory pension scheme is in operation.

Sporting and social facilities are excellent, providing a wide variety of activities on a large and well appointed sports ground.

Applications giving full details, should be sent to the Labour Manager at the above address. L 642

SENIOR DRAUGHTSMAN with checking experience, capable of filling responsible position in Gas Turbine Design Office. Applicants would be required to undertake some drawing with main duties checking a variety of work on turbines, controls and heat exchangers. Designer/Draughtsman and Detailers also required. Posts pensionable. Excellent recreational facilities available.—Application forms can be obtained from ASSISTANT MANAGER OF INDUSTRIAL RELATIONS, RUSTON & HORNSBY LIMITED, LINCOLN. L 742

DESIGN DRAUGHTSMEN required by old-established general engineering firm, S.W. London district. Must be fully experienced and have a good knowledge of workshop practice. Commencing salary £750 p.a.—Apply BOX L 754, Offices of ENGINEERING.

CONTRACTS MANAGER required by a well established heavy General Engineering Company with an international reputation in the manufacture of mining plant, water turbines and special engineering projects. Applicants must have first-class commercial and technical background with proven administrative ability backed by a wide practical experience of handling large and small contracts at a high level.—Applications with full details, which will be dealt with in strict confidence should be addressed to BOX 191, R. ANDERSON & CO., 14, WILLIAM IV STREET, LONDON, W.C.2. L 700

ASSISTANT WORKS MANAGER required by old-established firm of Engineers, S.W. London district, employing 450. Must have good knowledge of capstans, autos, mills, drills, sheet metal work, polishing, plating. Commencing salary £900 per annum. Good prospects.—Apply BOX L 753, Offices of ENGINEERING.

WILTON ICI WORKS

ELECTRICAL, MECHANICAL AND INSTRUMENTATION ENGINEERS

For engineers direct from the University, or for trained Mechanical Engineers with industrial experience, the chemical industry provides opportunities for a satisfying and well paid career. At Wilton during the last ten years many plants of great technical interest have been erected and plans made for further continuous development over a number of years. Here there are vacancies for Engineers on design, construction, and operation, with opportunities for training and advancement to managerial positions.

The chance to take part in this enterprise should particularly attract men graduating in 1956. Starting salaries are good and, should it be necessary, there are opportunities of gaining practical experience in a course which will initiate men into industry and be acceptable to the chartered engineering institutions.

This modern factory is situated at the foot of the Cleveland Hills within easy reach of the Yorkshire Coast. Working conditions are excellent and recreational facilities including golf, tennis and squash are available. After joining the staff, married men will receive a reasonable refund of removal (including travel) expenses; to assist in house purchase, facilities are available in approved cases for loans; in addition, legal charges may be advanced.

The appointments are permanent and include membership of the Staff Pension Fund and participation in the Employees Profit Sharing Scheme.

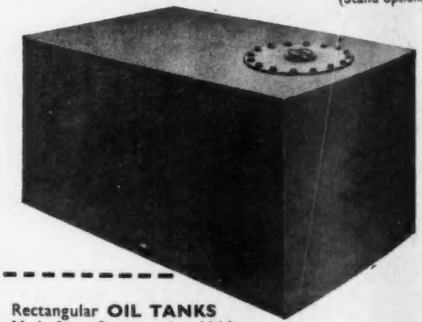
Any Engineering Graduate who is interested in a career which will combine interesting and productive work with prospects of steady progress should write to: STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES, LIMITED, WILTON WORKS, MIDDLESBROUGH, YORKSHIRE, quoting advertisement reference ICI/X/303/f. L 540

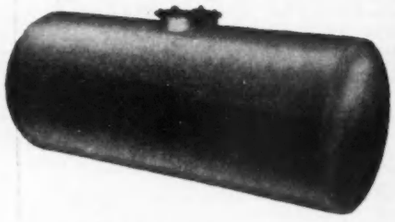
With every CONVERSION and every new installation of

OIL-FIRED BOILERS

for Central Heating comes the need for EFFICIENT FUEL STORAGE

600-gallon **FUEL TANKS** (Top left)
Single compartment welded horizontal circular Oil Tanks, with ends dished and flanged. 6in. dia. raised neckpiece for filling and necessary sockets for outlets, etc. Length 7ft. 1½in. Dia. 4ft. 6in. Plate ¼in. (Stand optional)





Rectangular **OIL TANKS**
Made from finest quality Mild Steel and available in thirteen capacities from 100 to 1,000 gallons and in several gauges. (Please write for List and Prices.)

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Horizontal with ends dished, and tested to 18 lbs. per square inch pressure. Available in capacities from 250 to 5,000 gallons, in single, double or triple compartments.

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SENIOR WORK STUDY ENGINEER.

Applications are invited from suitably qualified work study engineers, preferably between the ages of 30 and 35 years, for a position as Senior Work Study Engineer in a responsible, well organised and progressive company of building and civil engineering contractors employing about 1500 people, mainly in Yorkshire.

In addition to occupying a leading position in building and civil engineering, the company and associated companies are also engaged in the manufacture of joinery, concrete and clay products and light engineering.

This is the senior position in a growing department and offers an excellent opportunity to take part in the development of a new field for the application of work study to a continuing variety of both indoor and outdoor work.

Some work study has been carried out and excellent labour relations exist within the company. The department has the full support and understanding of the Directors who also appreciate the long-term nature of this work.

Applicants must have a minimum of five years' sound and varied experience in work study and the ability to handle staff but previous building experience is not necessary. The post will involve travelling within a limited radius of our Head Office. A car will be provided and assistance will be given with housing if required.

This is a permanent post offering progressive salary, annual bonus and generous pension and life assurance scheme. Written applications in confidence, stating age, details of experience, some indication of commencing salary required should be addressed for the personal attention of

P. M. SHEPHERD, MANAGING DIRECTOR,
F. SHEPHERD & SON, LTD.,
BLUE RIDGE LANE, YORK. L 716

CLERKS REQUIRED IN COST AND ACCOUNTS DEPARTMENT, Engineers, Staines area. Good prospects. Pension Scheme.—Write full details, age, experience, salary required to the SECRETARY, ROTINOFF MOTORS, LTD., 125, PALL MALL, S.W.1. L 723

MANAGEMENT SELECTION LIMITED have been retained to advise on the selection of the

CHIEF ENGINEER

for a large chemical manufacturing company based on London. Products include a wide range of fine and heavy chemicals. Existing works and planned extensions cover more than 70 acres. The person appointed will be responsible to the Works Director for the design, construction and maintenance of all plant and buildings at all works, including general supervision of contractors on major projects.

Candidates must be graduate mechanical engineers with wide experience of similar work in a chemical process type of industry. Knowledge of electrical and civil engineering must be adequate to direct the work of graduates in these fields. For good reasons of internal policy the minimum age is 50. Salary and special pension arrangements will be subject to discussion, but initial salary will be about £3000.

M.S.L. would be glad to have brief details, strictly related to these requirements, from anyone so qualified. No information will be passed to our clients without candidate's permission.

Please write marking the envelope "Confidential," to MANAGEMENT SELECTION, LTD. (F.119), 8 CLARGES STREET, LONDON, W.1. L 691

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Have you looked round your stores recently and made sure that you are not losing money every day through rust damage to metal parts? Rust is an ever-present danger, yet it is so easy to prevent. One application of a suitable RODOL grade by spray, by dipping, by brush or by wiping gives positive protection to ferrous parts and assemblies for months. RODOL can save money in your works so it is worth looking into. Write for details and samples.

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A WELL KNOWN FIRM making Mechanical Presses and Special Machines, including "Automation" Equipment, has

VACANCIES IN ITS DESIGN OFFICE. Interesting and creative work with opportunities for independent constructive thinking. Young men in course of training would be considered.—Apply stating experience, etc., to BOX L 752, Offices of ENGINEERING.

BRUSH ELECTRICAL ENGINEERING CO., LTD., have vacancies for men of ambition seeking progressive and responsible positions as

TENDERING AND CONTRACTS ENGINEERS in their Commercial Departments at Loughborough. Applicants should be capable correspondents with experience in one or more of the following: turbo-alternators, rotating machines, switchgear or transformers. Additionally, vacancies exist in the General Engineering Division for men having specialised knowledge of comprehensive power schemes for both diesel and steam generating stations. Appointments will be of a permanent nature with good salaries, and excellent prospects are open to suitable men. Conditions of service include non-contributory staff assurance.—Please write with full details in confidence to the CHIEF PERSONNEL OFFICER, BRUSH ELECTRICAL ENGINEERING CO., LTD., LOUGHBOROUGH, LEICS. L 764

MANAGEMENT AND INDUSTRIAL CONSULTANTS

engaged in all types of Production, Organisation, Administrative and Costing functions are open to

ENGAGE ADDITIONAL STAFF. Applicants must possess highest technical and professional qualifications in Engineering or Accountancy and should have practical managerial experience. Age not over 40. Remuneration on a high scale with superannuation and expense allowances.—Full details of qualifications and experience to BOX L 737, Offices of ENGINEERING.

ESTIMATOR required, London area. Heavy Mechanical Engineering experience and knowledge of gearing essential.—Write giving full details of experience, salary required and age to: THE SECRETARY, THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON, MIDDLESEX. Property for rental would be made available to suitable applicant. L 680

SENIOR DRAUGHTSMAN required, London area. Heavy Mechanical Engineering experience essential, knowledge of gearing an advantage.—Write stating age and salary required and giving full details of experience to THE SECRETARY, THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON, MIDDLESEX. Property for rental would be made available to suitable applicant. L 681

Marine Engineering Company constructing main steam turbines and diesel machinery, watertube boilers, etc., for largest sizes of warships, passenger ships and oil tankers requires a

GENERAL MANAGER to supervise the Works and to be responsible for production to the Managing Director.—Applicants please state age, qualifications, experience and an indication of salary required to BOX L 715, Offices of ENGINEERING.

ENGINEER MANAGER.

Applications are invited from fully qualified Engineers for the post of Engineer Manager with Baghdad Electricity Services. Applicants, aged 35 to 45 years, should have experience in all branches of an Electricity Supply Undertaking, including administration, distribution and generation by oil-fired boilers and turbo-alternators. Experience in the erection of plant will be an advantage. Three-year contract in first instance at a net salary of approximately Iraqi Dinars 270 (£270) per month including high cost of living allowance. Provident Fund exists. Free house with heavy furniture provided. Three months' leave on full salary after completion of 24 months' service in Iraq with first class passages including wife and family.—BOX L 693, Offices of ENGINEERING.

DISTRIBUTION ENGINEER.

Applications are invited from qualified Engineers for the post of Distribution Engineer with Baghdad Electricity Services. Applicants, aged 30 to 40 years, should have experience in all branches of an Electricity Distribution System, including 33-kV, 11-kV, L.T., underground cables and overhead lines, sub-stations, maintenance and erection. Experience in generating plants is not required but will be an advantage.

Three-year contract in first instance at a net salary of approximately Iraqi Dinars 200 to 225 (£200 to £225) per month according to qualifications, including high cost of living allowance. Provident fund exists. Free house with heavy furniture provided. Three months' leave on full salary after completion of 24 months' service in Iraq with first class passages including wife and family. L 694

ENGINEERING DRAUGHTSMEN, preferably with mechanical or electrical experience, required for established chemical and process engineers. Approximately six months in North Gloucestershire and then permanently at North-West Surrey. Good salary, prospects and canteen. Five-day week. —Apply BOX L 695, Offices of ENGINEERING.

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Expanding Drawing Office (Newcastle) requires Design Draughtsmen for Jig and Tool Work, and for the design of special purpose Boring and Milling Machines.

Salaries in accordance with educational standard and experience. Permanent positions in long established concern for suitable applicants. Pension and Welfare facilities available.

Please give age, education, experience, etc.—Write BOX L 759, Offices of ENGINEERING.

Classified Advertisements continued on Page 123

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Machinery and Equipment for Mining, Oil, Metallurgical and Electrical Industries, Power Plants, Pumping and Compressor Installations, Hoisting and Transporting Units, Chemical Equipment and Equipment for Light Industries
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BUT:—this efficiency means that more of the impurities are arrested so that it is inevitable that the time when they cause the flow to be diminished arises sooner than with less efficient filtration.

Therefore—to obtain the most efficient filtration be prepared to change the element more often.

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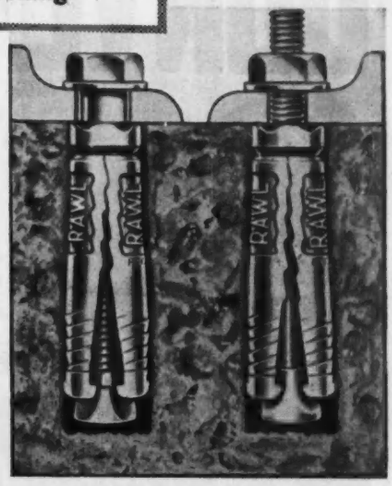
Rawlbolts are made in all sizes from ¼in. to 1in. bolt diameter, Whitworth thread. There are two types, Bolt-projecting and Loose-bolt. The latter is specially useful for heavy equipment because bolts can be inserted after the fixture has been placed in position.



If you have a fixing problem, write to our Technical Service Department. They will be delighted to help you.

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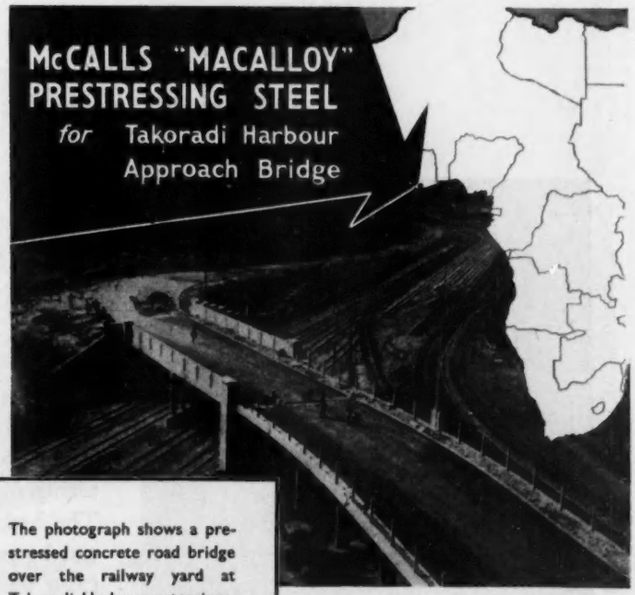

The photograph shows a prestressed concrete road bridge over the railway yard at Takoradi Harbour extensions, Gold Coast Colony. The precast beams of the bridge are of 44-ft. span, each post-tensioned with 3in. to 1⅛in. diameter Macalloy bars.

Designed by Rendell, Palmer and Tritton, Consulting Engineers to Gold Coast Railways and Harbours Administration, and making use of the Lee-McCall system, the bridge was constructed by Taylor Woodrow (West Africa) Ltd.

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FC32

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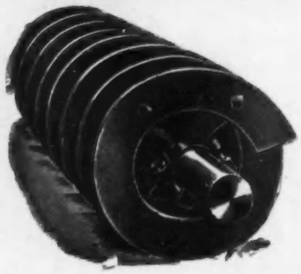

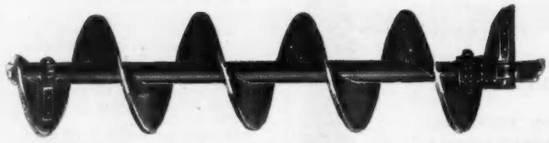

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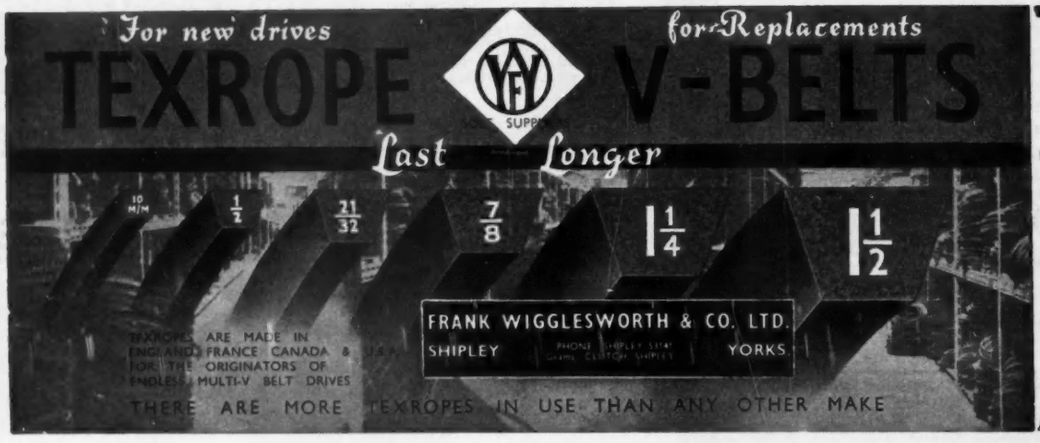
BUCKET ELEVATORS, Etc.



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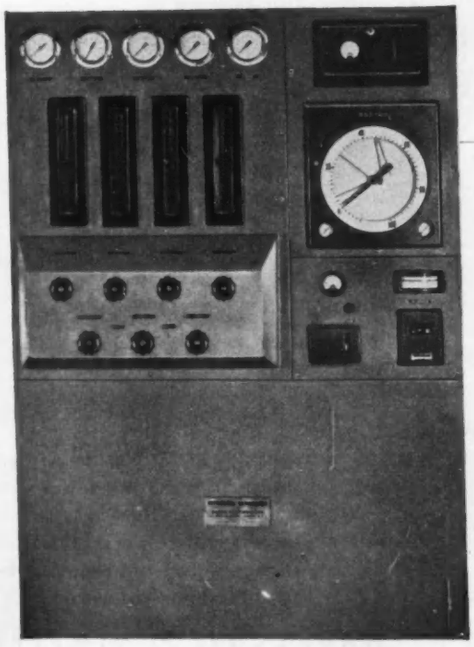

for producing PURE NITROGEN with a controllable hydrogen content

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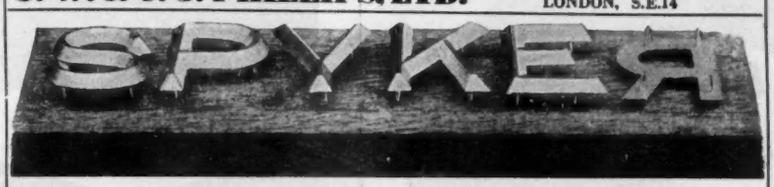

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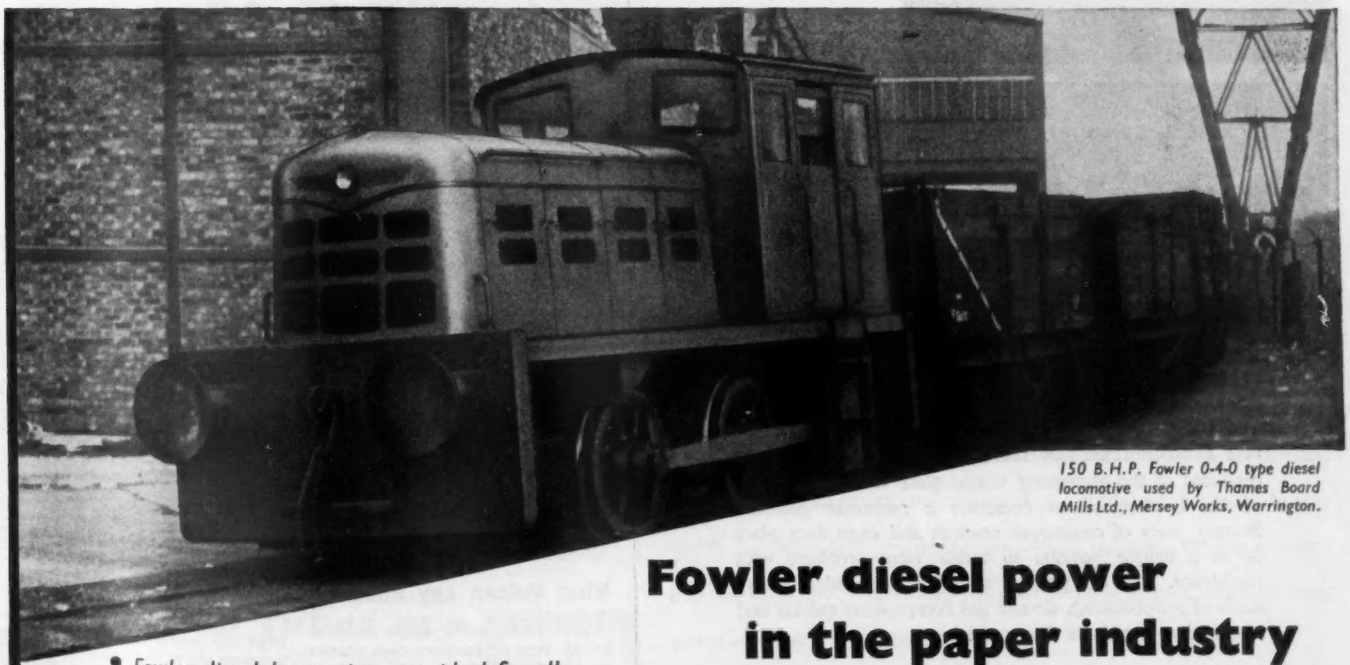

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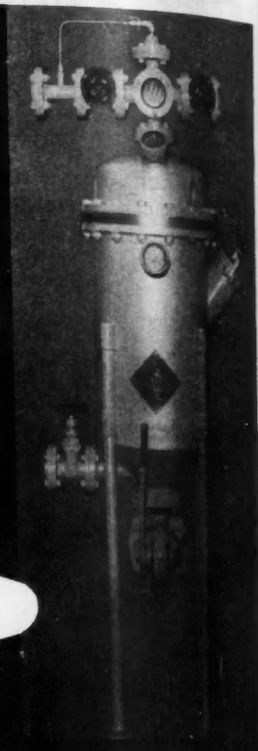

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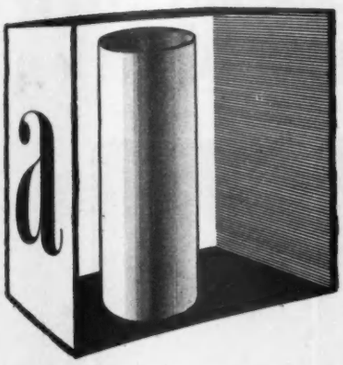
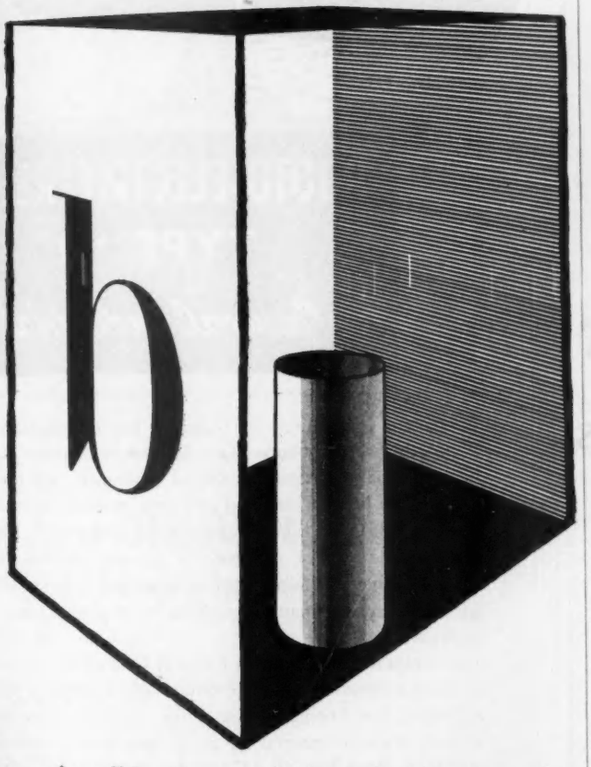


*which is biggest?**



When you're talking (as we are) about the biggest seamless steel tubes, the answer's to be found in our works at Chesterfield. Here we have a 5,000 ton piercing press that can knock out the heaviest of heavyweights in one punch. Solid steel billets weighing as much as 20 tons are punched, then drawn and machined to final dimensions to make the famous Chesterfield tubes—tubes that are as strong as they're hefty. A tube made by the Chesterfield process has no seam, no welds . . . and certainly no other contenders in its class in Britain.

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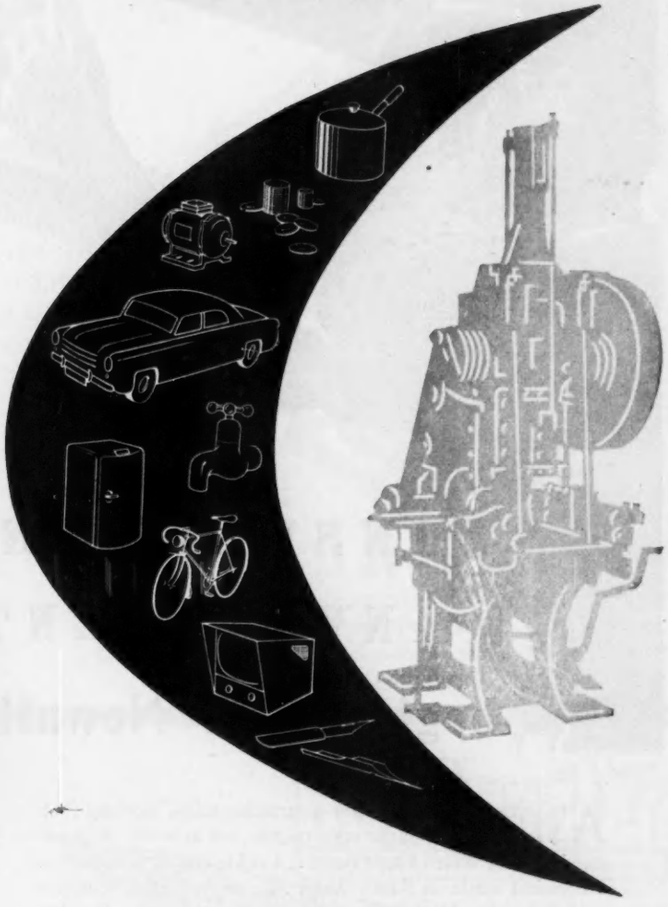
CRC 35

Pressure brought to bear



To make almost anything, if it is made from sheet metal or metal billets (hot or cold) or powdered metal, the simplest and most efficient method is to produce it with a Power Press; if the Press is fitted with automatic feeds for handling the material the production will be enormous. From experience we know that every Pressing problem needs special modifications according to specific requirements. However, we invite you to send for our set of catalogues which are completely descriptive and which illustrate both our range and our capacity. From them you may find the type of machine from which your own might be developed.

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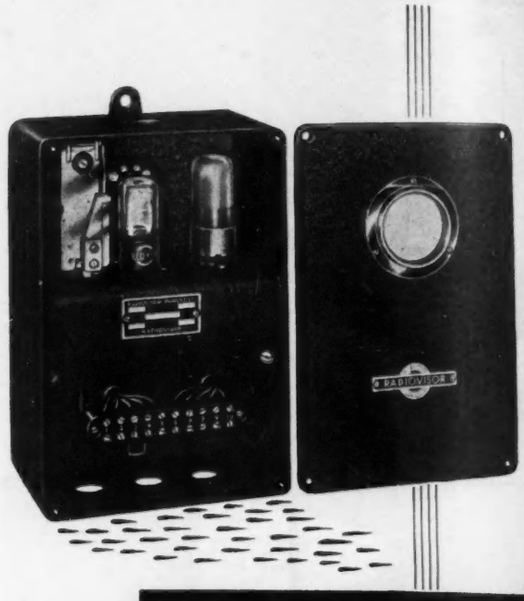

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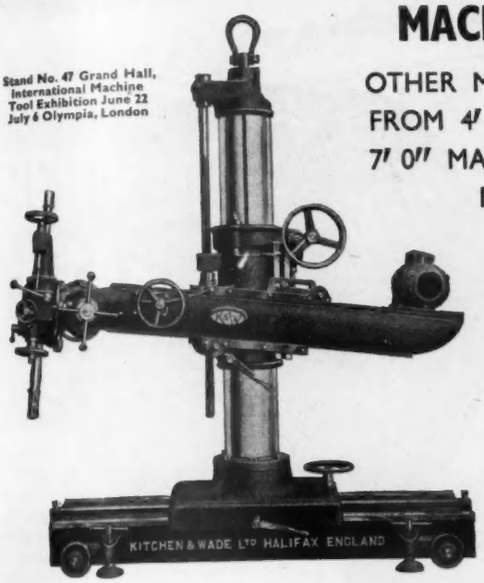

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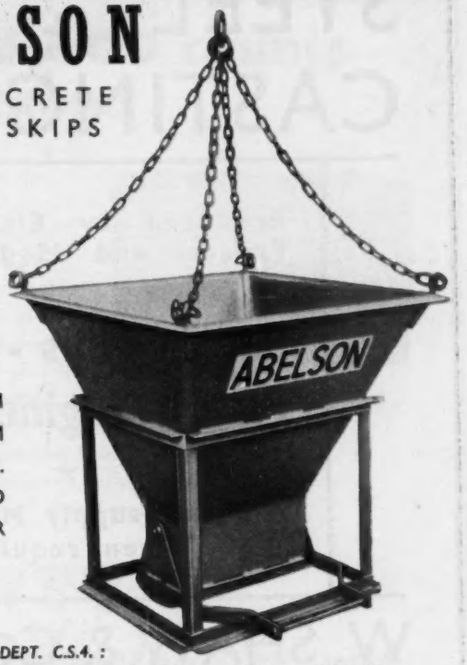

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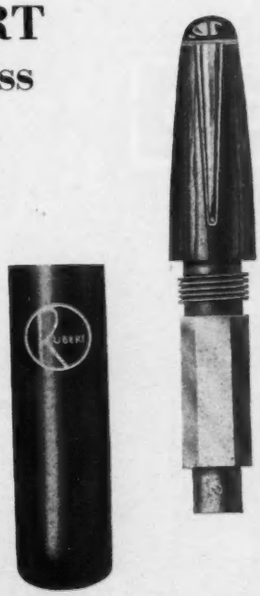
Model 42/S	£8.16.0

The new Models also contain surface Finish Colour Code.



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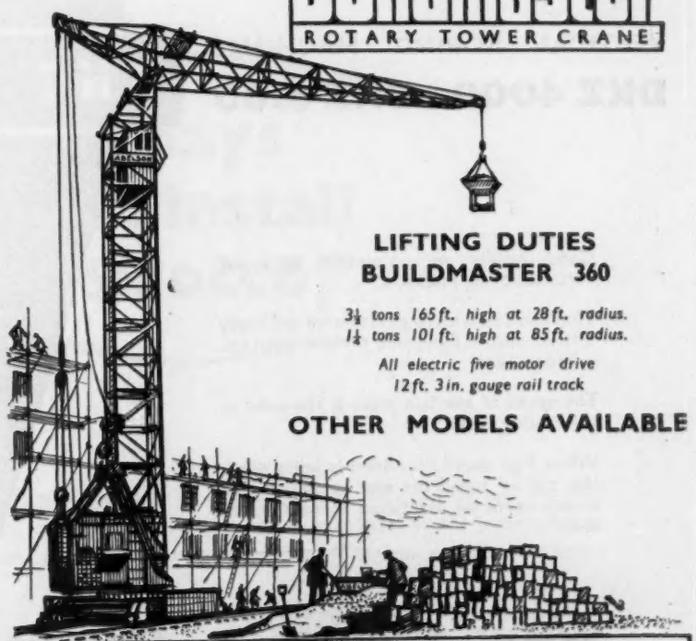

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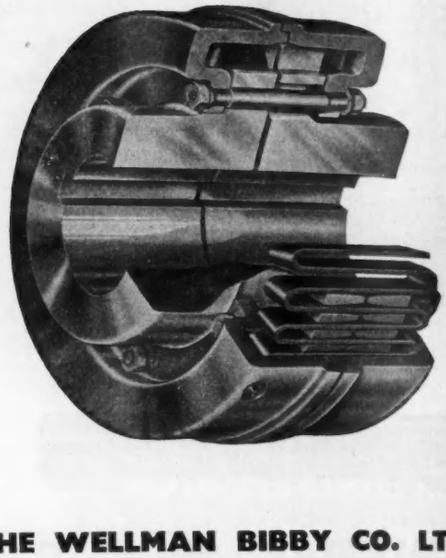

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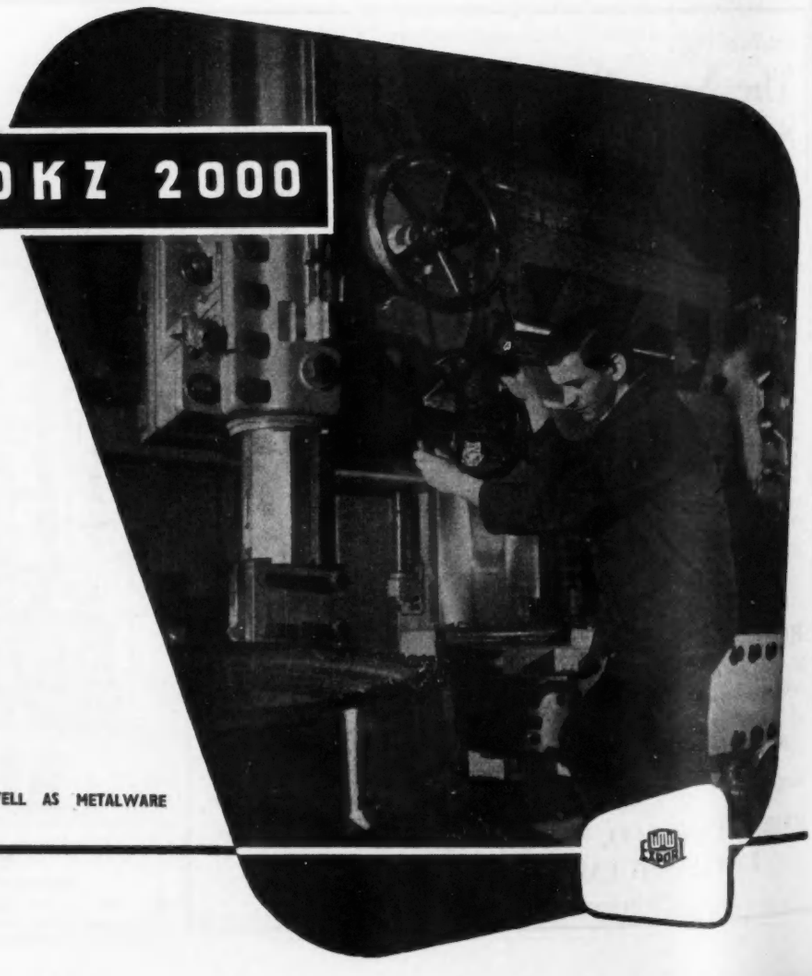

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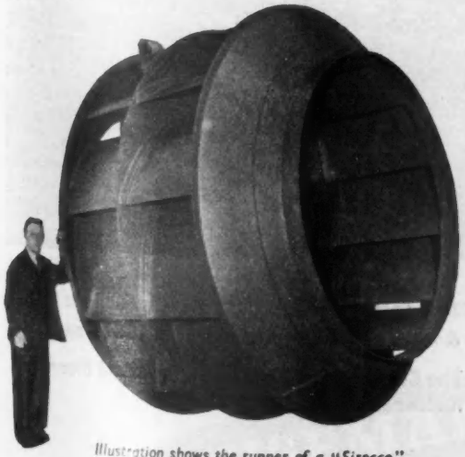

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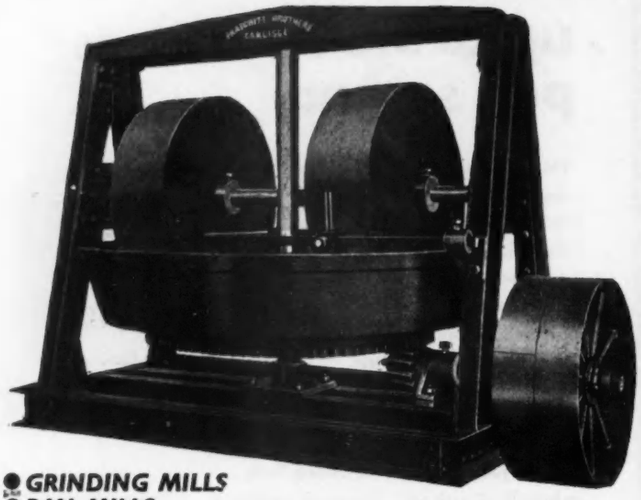

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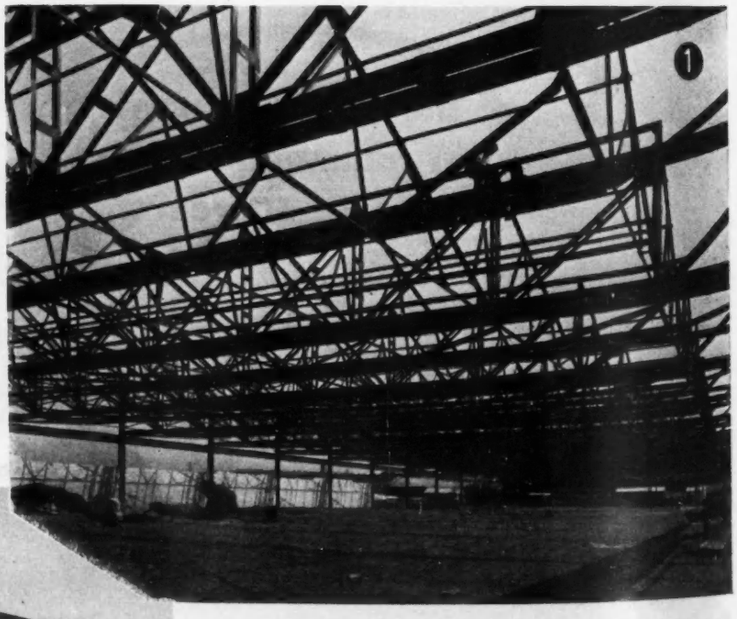

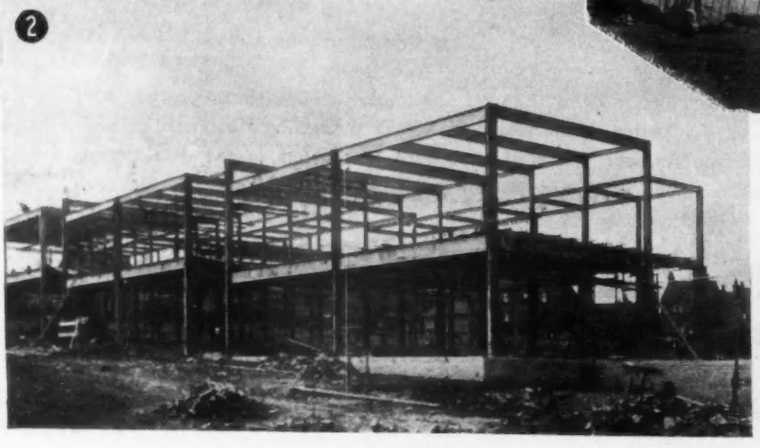

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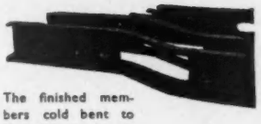
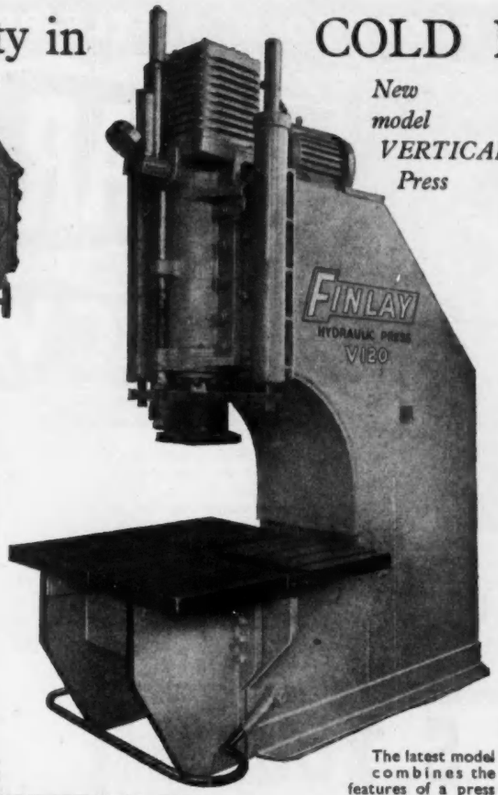
Euclid use Finlay Cold Bending machines to shape the two main chassis members of their F.D.T. tractor.



The finished members cold bent to shape in two minutes.

New model VERTICAL Press



The latest model combines the features of a press brake with those of the usual type of table press.

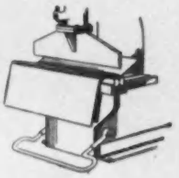
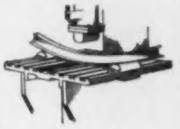
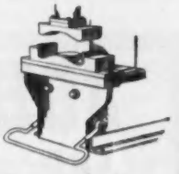


Plate bending up to 48" w'de by ½" thick.



Section Forming using straight faced blocks.



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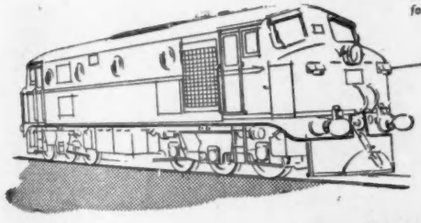

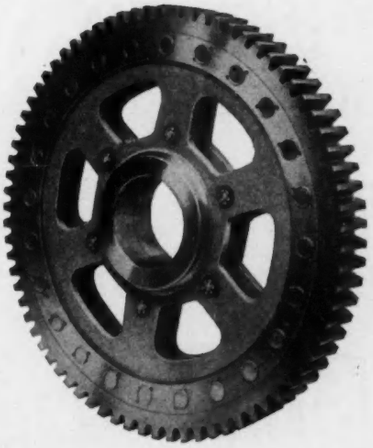

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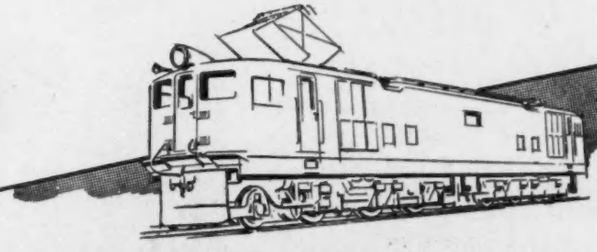

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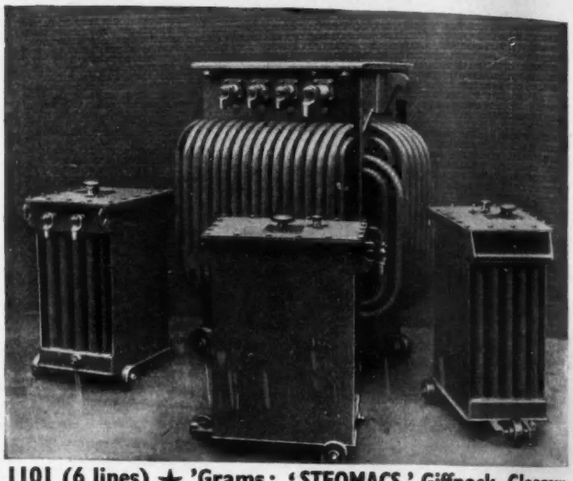

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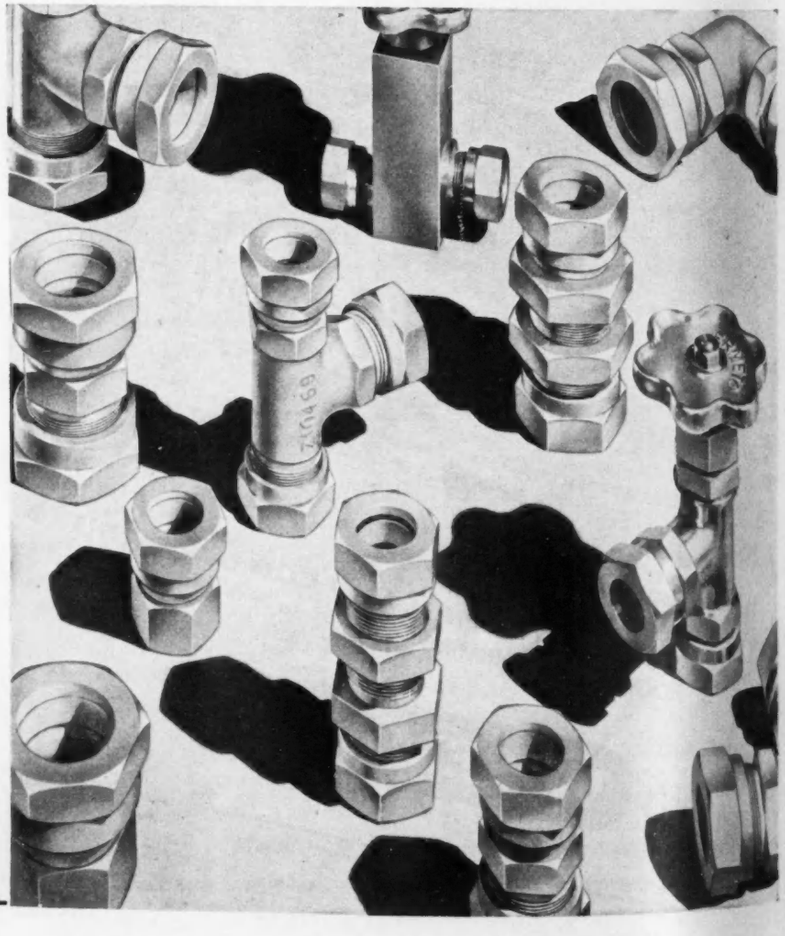

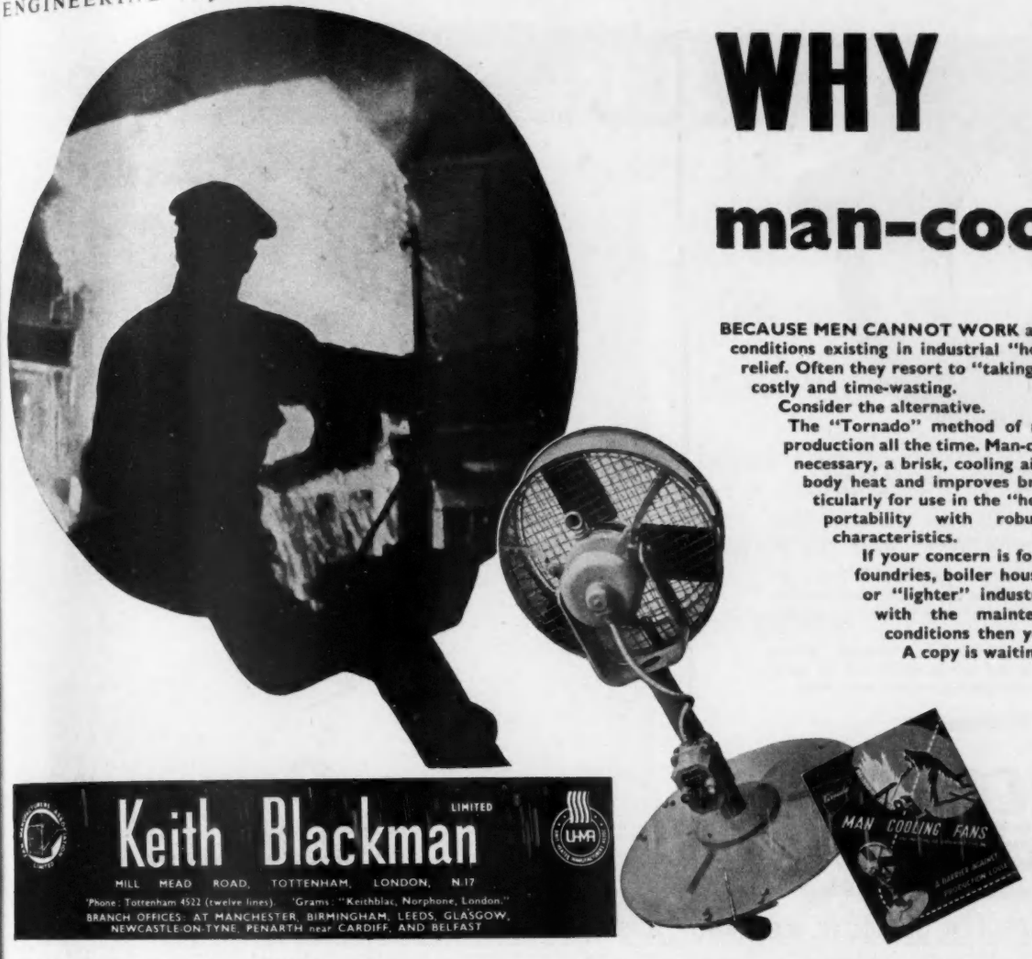

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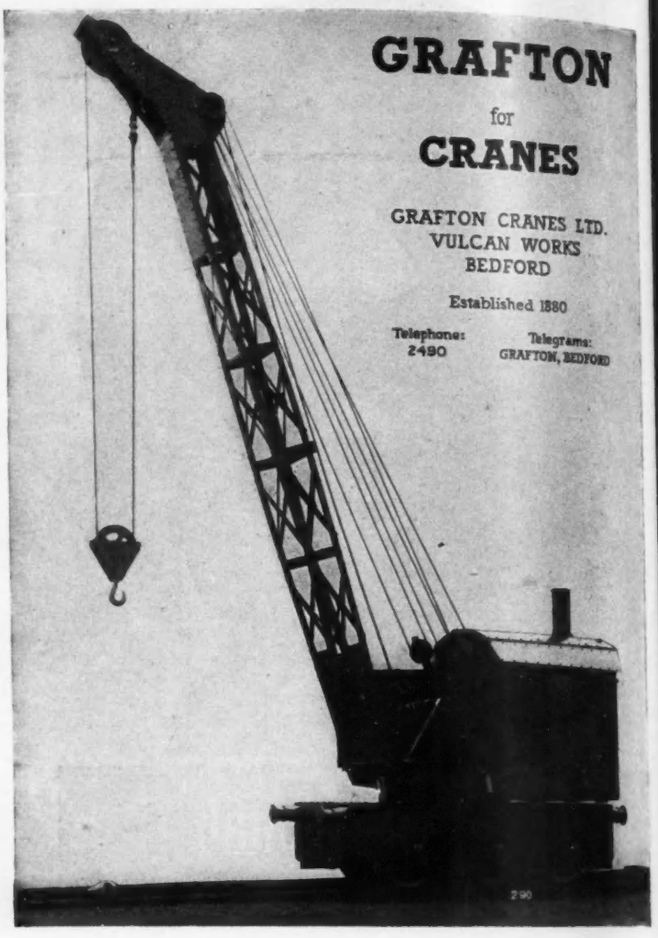
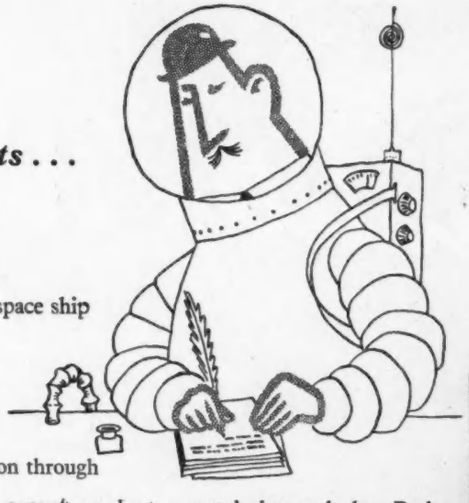


our outer space correspondent reports . . .



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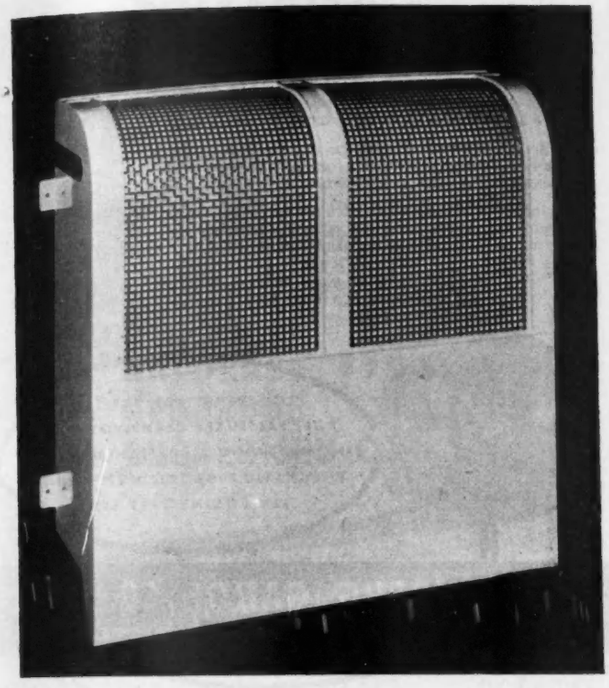

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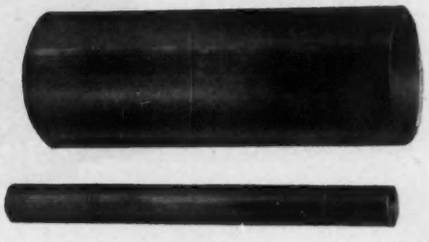

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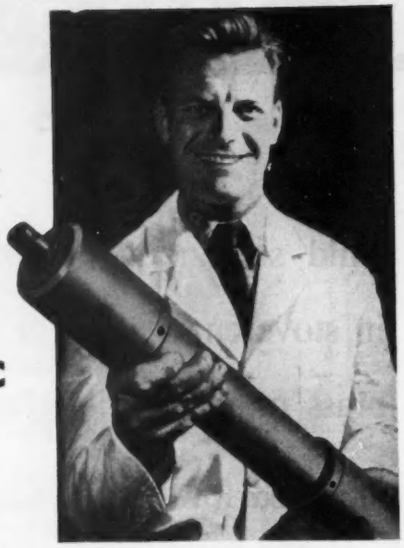

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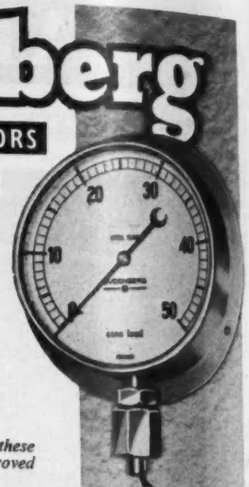

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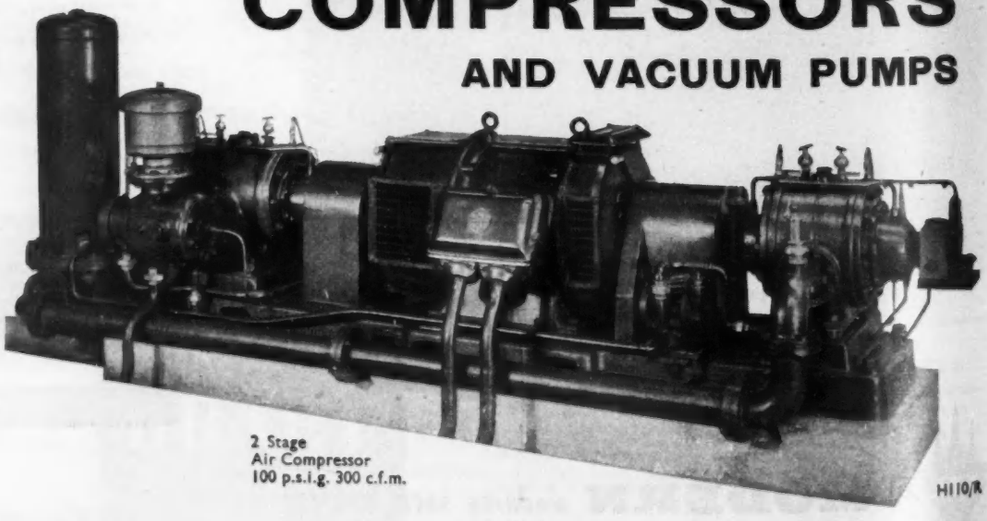

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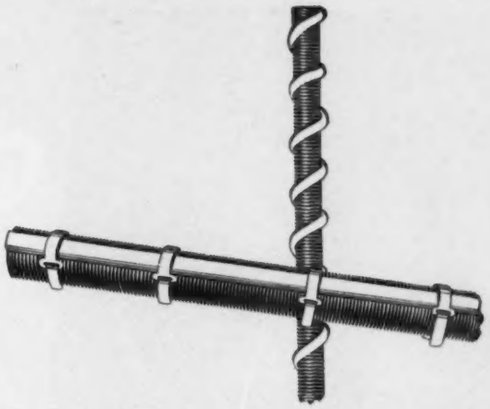

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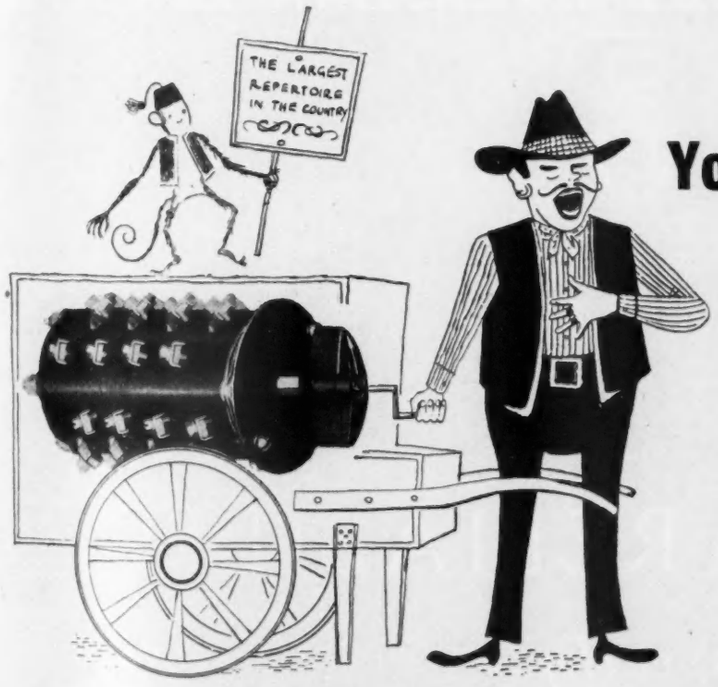

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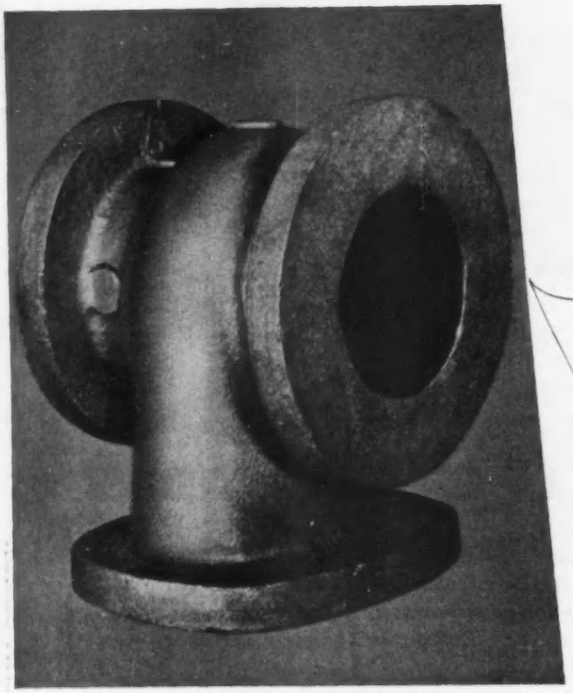

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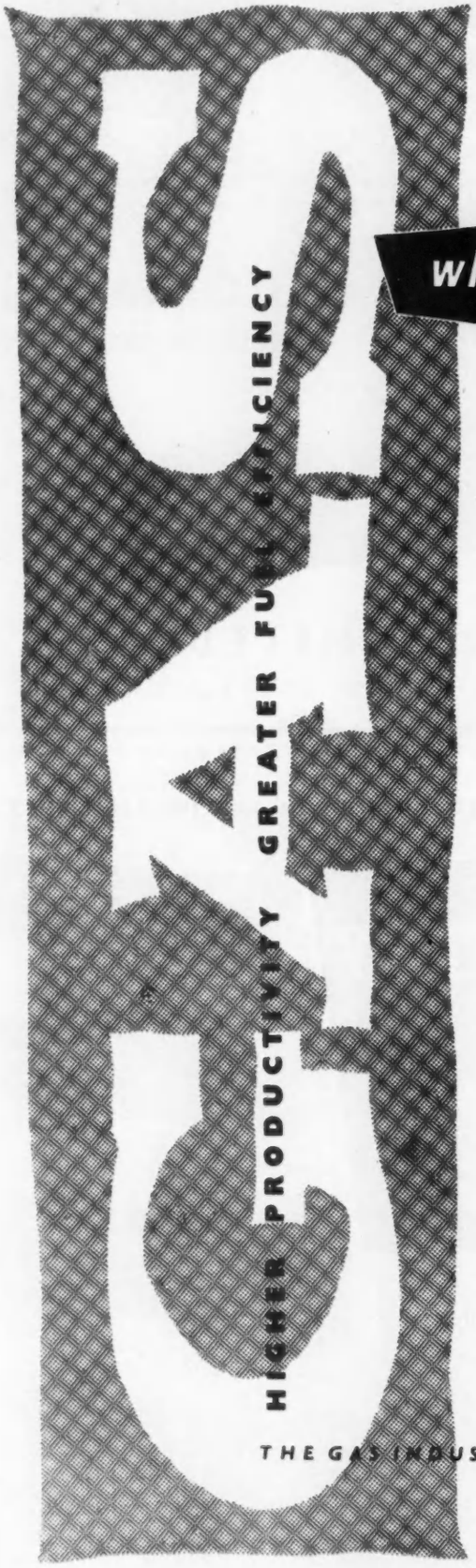

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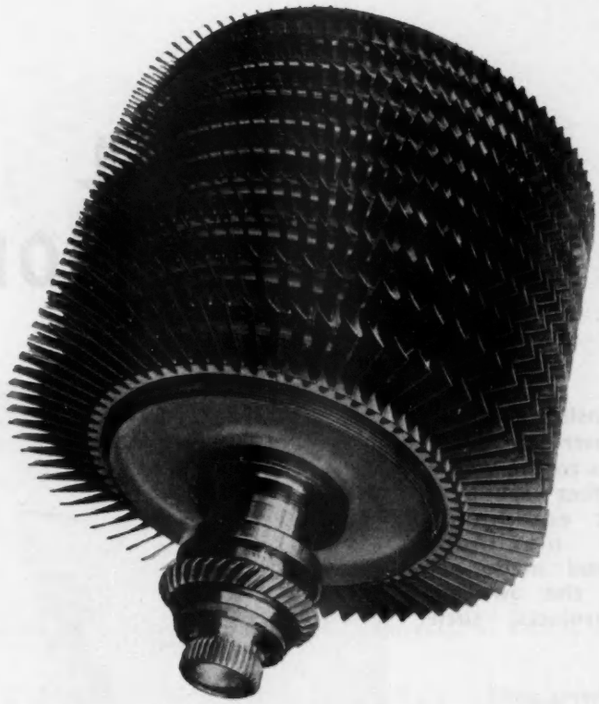

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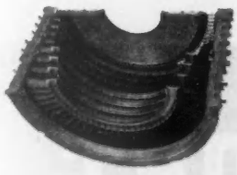

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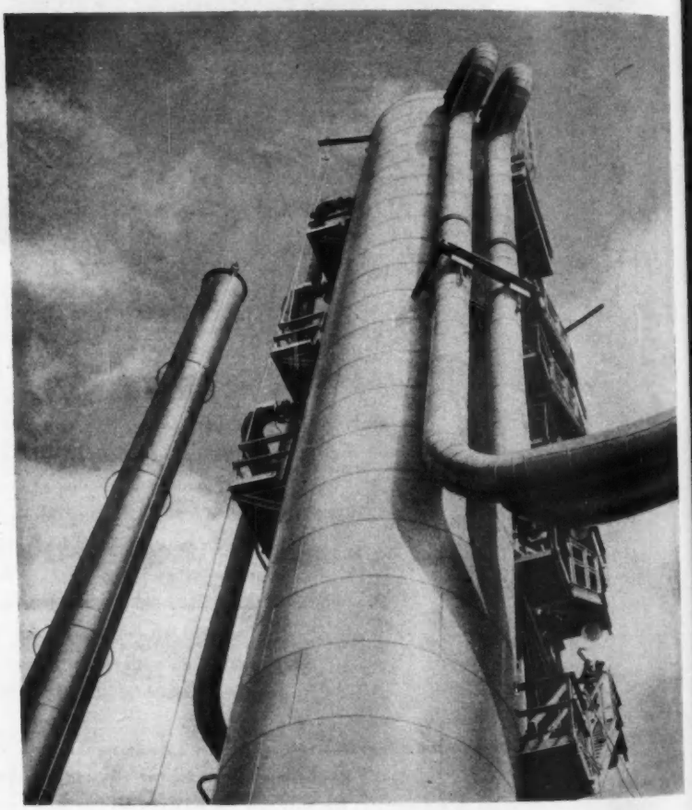

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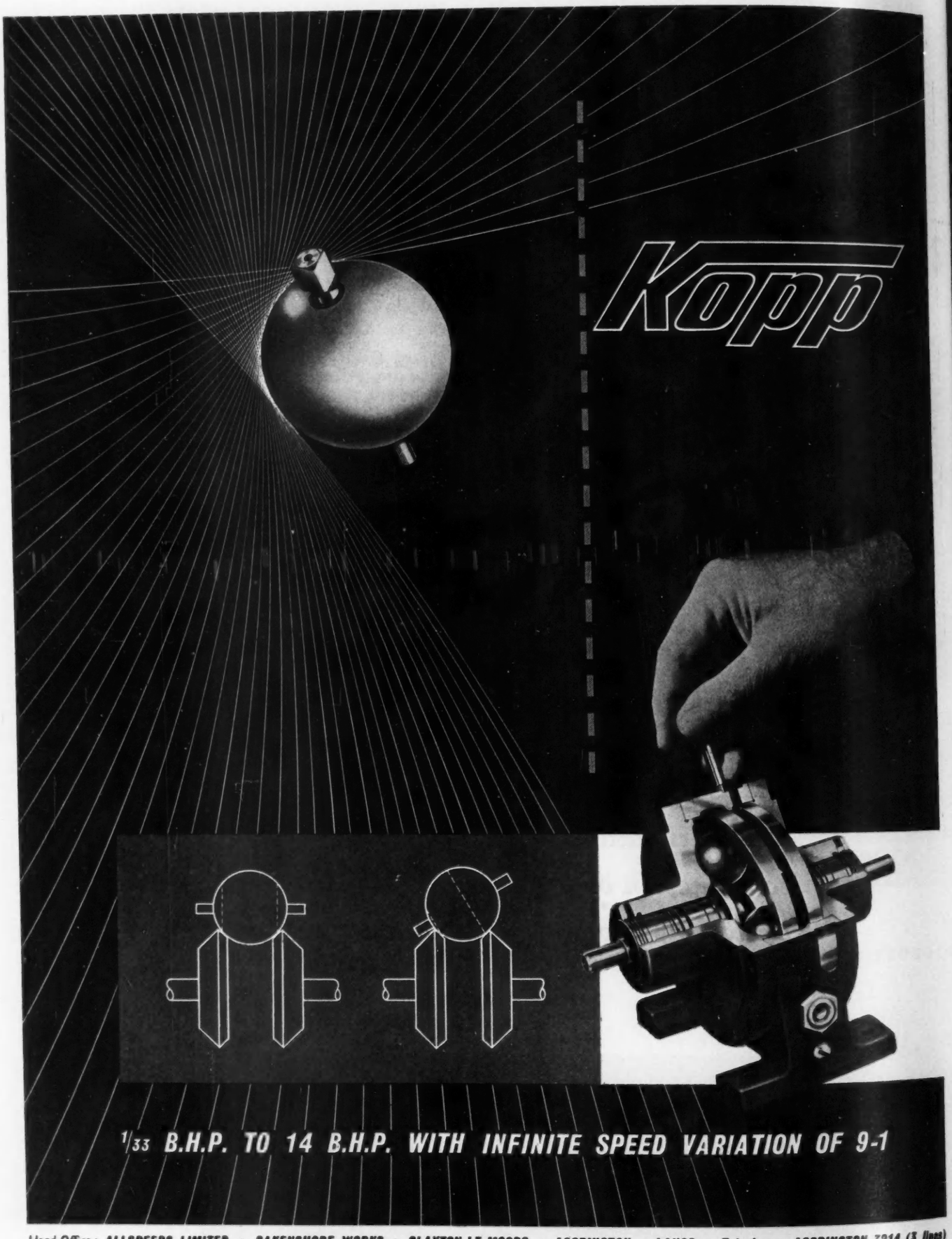

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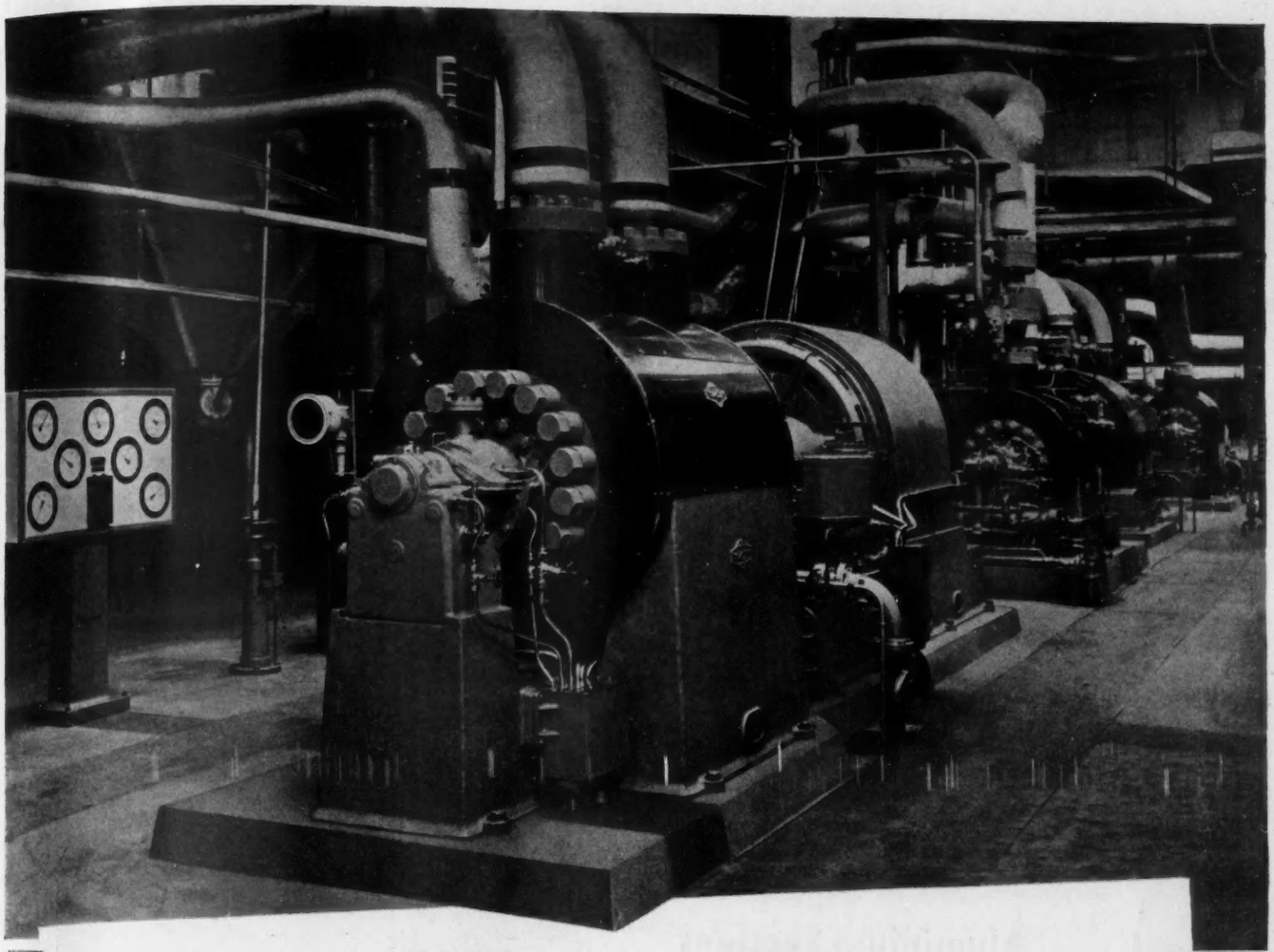

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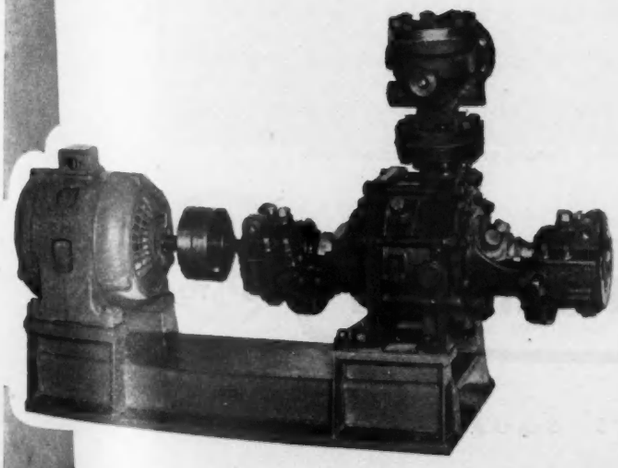

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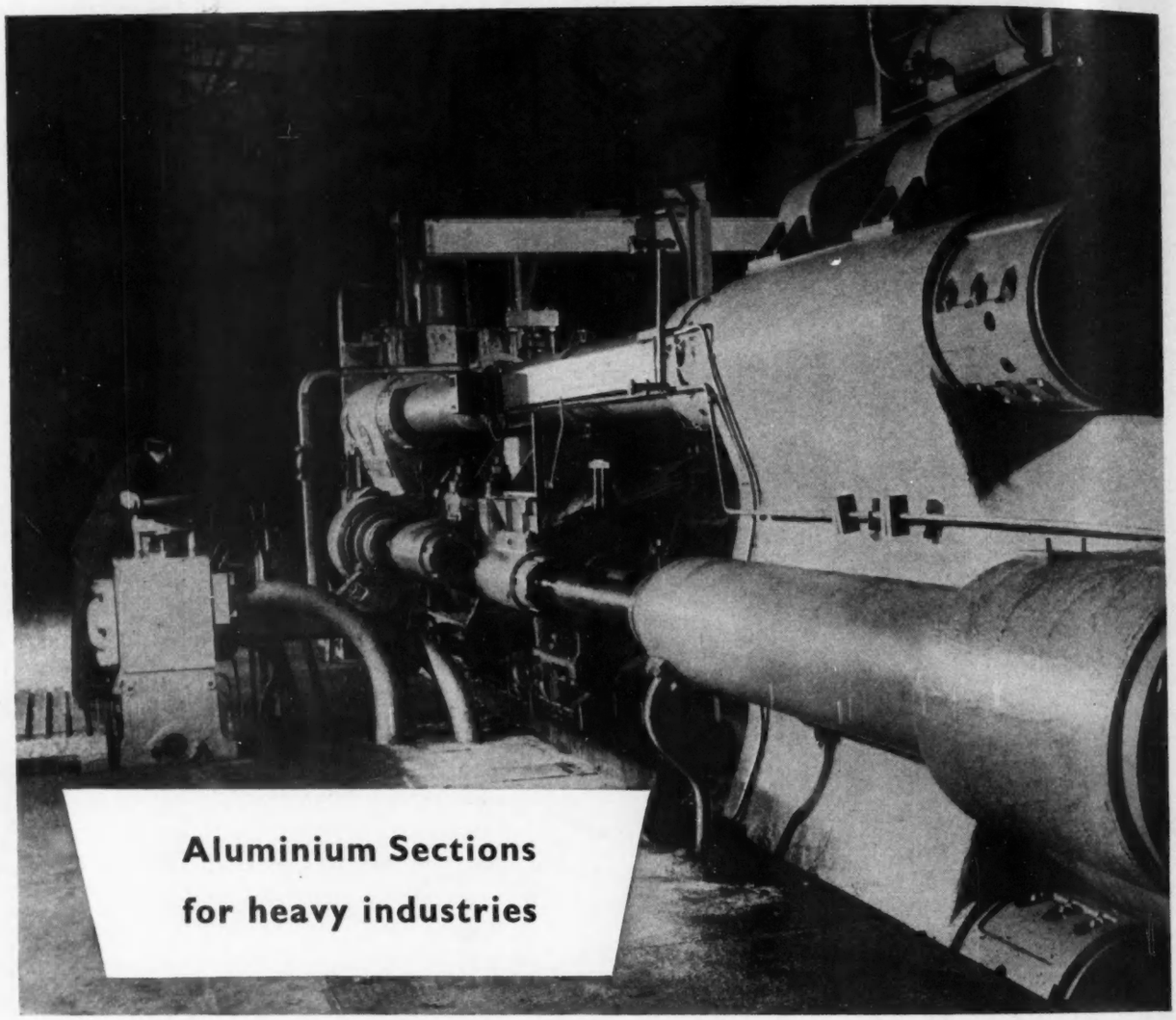
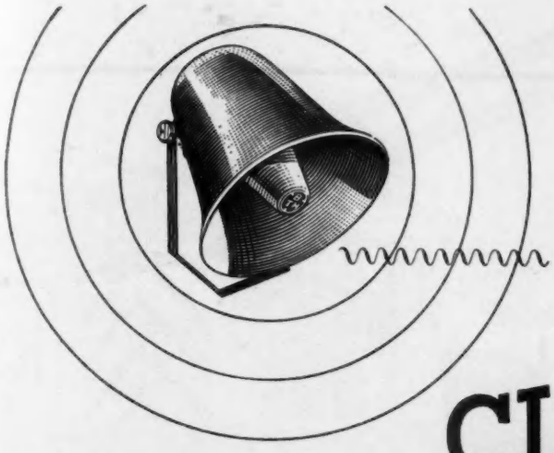


Two additional extrusion presses, one of 5,000 tons and the other of 3,500 tons, have been installed at the Latchford Locks Works of the British Aluminium Company. These presses represent an important extension to the extrusion capacity of the aluminium industry in this country. They will be used to produce a wide range of sections for the road transport, building, shipbuilding and structural and general engineering industries. Extrusions are available in sizes up to 13½" circum-circle and are specially designed to facilitate the economic use of aluminium in riveted or welded assemblies.

THE **British Aluminium** CO LTD

NORFOLK HOUSE ST JAMES'S SQUARE LONDON SW1

AP 130-1267



CLEAR AS A BELL

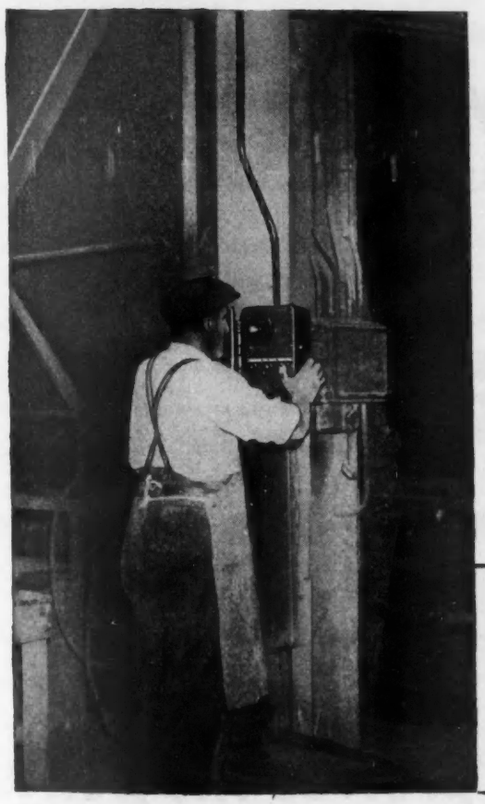
CLEARCALL

Industrial Communication System

With "Clearcall", speech can be clearly heard through the din of a noisy factory, or it can be adjusted for quiet surroundings.

"Clearcall" components are of rugged industrial design, and will not fail in spite of dirt, damp, and rough usage.

The equipment is suitable for iron and steel works, rolling mills, etc., paint and varnish factories, chemical works.



SAFE!

"Clearcall" components are the subject of an "intrinsic safety certificate" in respect of Pentane Vapour etc. Details on application.

THE
BRITISH THOMSON-HOUSTON
COMPANY LIMITED, RUGBY, ENGLAND

A 4582

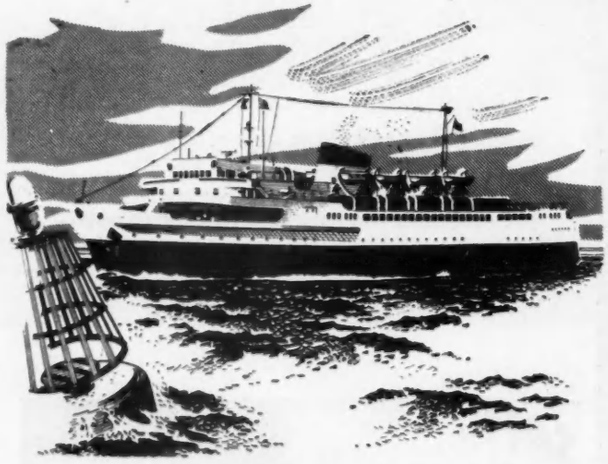
Member of the AEI group of companies

Whatever...

On land or at sea, National diesels are linked with the idea of Dependability—providing durable, economical power for transport of many kinds.

Brush-Bagnall locomotive equipped with National diesel engine.

and wherever...



With nearly 70 years of experience in internal-combustion engines, the National Company have embodied many special features in the design of their vertical engines which have pioneered new trends. National engines are available as straight diesels, pressure-charged units, dual-fuel engines, high compression gas engines and alternative-fuel engines, in their respective types for stationary use, transport, railway traction and marine purposes.

Canadian Pacific Passenger Vehicle and Train Ferry "Princess of Vancouver," with 9,600 b.h.p. of National propulsion and auxiliary diesel engines operating on heavy fuel.

NATIONAL

diesels

GAS AND DUAL-FUEL ENGINES

provide the power...

There is a wide range of National engines with outputs up to 2,000 b.h.p.

THE NATIONAL GAS AND OIL ENGINE CO. LTD., ASHTON-UNDER-LYNE, LANCASHIRE

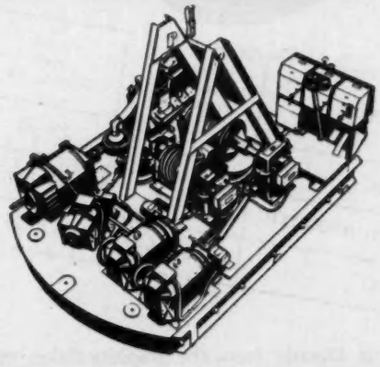
A Member of the BRUSH Group

NAT 3

This crane has everything plus

ELECTRIC TRANSMISSION

Independent electric motors provide power for all Coles crane motions. Accurate, time-saving creeping speeds and smooth acceleration result. Profit-consuming maintenance is reduced to a minimum by dispensing with complex gear trains and clutches, and a simple open superstructure design permits easy access to all components.



Demonstrations, technical advice, and prompt after-sales service are all at your disposal. May we have the pleasure of offering you one or all three.

THE NAME THAT CARRIES WEIGHT

COLES

Designed, manufactured and marketed by:-

STEELS ENGINEERING PRODUCTS LIMITED

Sunderland, England **Tel: 56281 (10 lines) Grams: Steel, Sunderland**

SALES AND SERVICE: **London:** 6 Avonmore Road, W.14 **Birmingham:** 39 Thorp Street, 5
Manchester: 153 Oxford Road, 13 · **Newcastle:** Brunswick House, Brunswick Place · **Glasgow:** 235 Bath St., C.2

Lloyds Ductile Iron

has a greater tensile strength than some steels with the castability and machineability of iron

GRADE	Ultimate Tensile Stress Tons/sq. in.	Yield Stress Tons/sq. in.	Elongation % (on 2 in.)	Transverse Rupture Stress Tons/sq. in.	Compression Strength Tons/sq. in.	Impact Izod. 10 mm. sq. notched ft. lb.	Brinell Hardness
PEARLITIC	35–45	25–35	1–5	55–65	65–80	4	230/280
PEARLITIC/FERRITIC	32 min.	24 min.	5 min.				
FERRITIC	27/35	20/25	10/25	55/60	48/58	12	140/180

With Lloyds Ductile Iron, the graphite flakes common to ordinary cast iron are present in the form of spheroids. It can be cast as accurately and as easily as ordinary cast iron, but compared with flake-graphite iron is stronger, tougher and ductile.

Lloyds Ductile Iron is now being used for a wide range of engineering parts and in some instances is replacing cast or forged steels, malleable iron and non-ferrous metals. It also replaces grey iron, permitting reduced section thickness to take advantage of the better properties offered and it may well enable you to re-design your present castings for more efficiency.

The successful casting of Ductile Iron demands the strictest and most experienced metallurgical and melting control, but Lloyds have been casting it daily, continuously since 1950! Technical advice freely given on request.

CYLINDER BODY in Ductile Iron. Weight 30 lbs.

TRANSMISSION BEARING in Ductile Iron. Weight 50 lbs.

Lloyds of Burton

Ductile Iron is only one of the range of High Duty Irons cast by Lloyds

LLOYDS (BURTON) LTD., WELLINGTON WORKS, BURTON-ON-TRENT · TELEPHONE: BURTON 3867

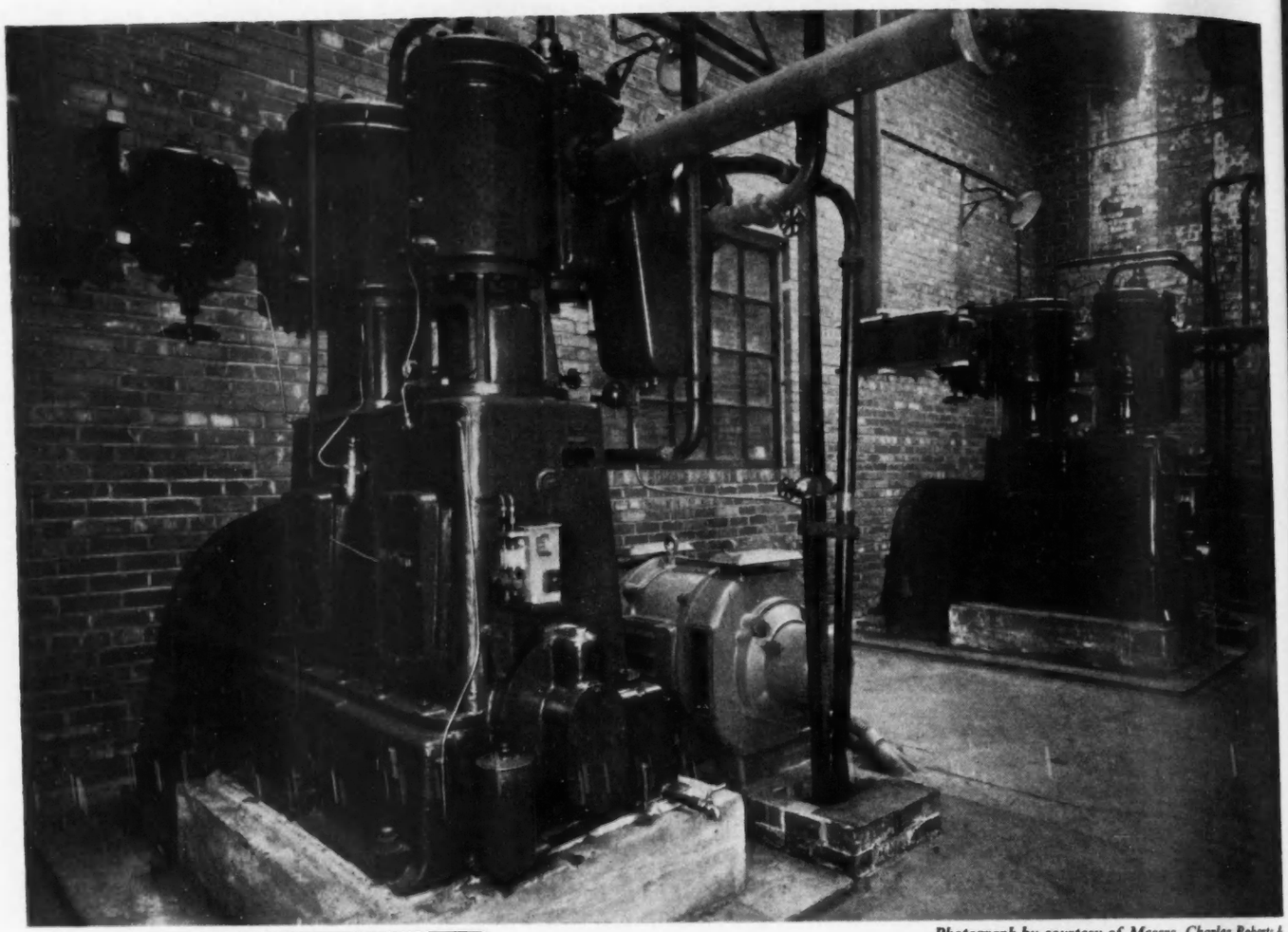
A Print for Industry Ltd. advertisement

The Steel Company of Wales Limited

Sheet steel and tinplate of the highest quality

ENQUIRIES SHOULD BE ADDRESSED TO

The Sales Controller
The Steel Company of Wales Ltd
136 Regent Street, London W.1



Photograph by courtesy of Messrs. Charles Roberts & Co. Ltd., and Metropolitan Vickers Electrical Co. Ltd.

"BROOMWADE" aids Industry

. . . AT RAILWAY ROLLING STOCK WORKS

Two " BROOMWADE " type TS2 stationary air compressors, each delivering 730 cu. ft. of free air per minute, and powered by Metro-Vick type R.W. slip-ring motors, speed the construction of a variety of rolling stock for home and overseas railways.

They power a wide range of pneumatic tools for riveting, chipping, caulking, drilling, the operation of forging hammers, moulding machines and shot blasting.

" BROOMWADE " air compressors and pneumatic tools are boosting output for industry all over the world—reducing production costs and making the most of available labour resources.

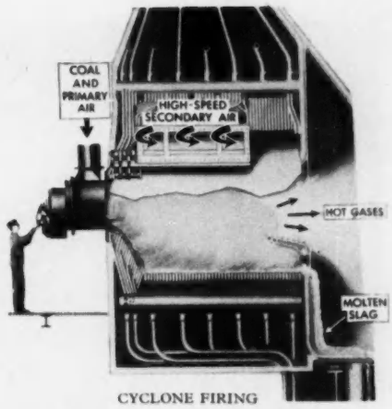
"BROOMWADE"

Speeds the job

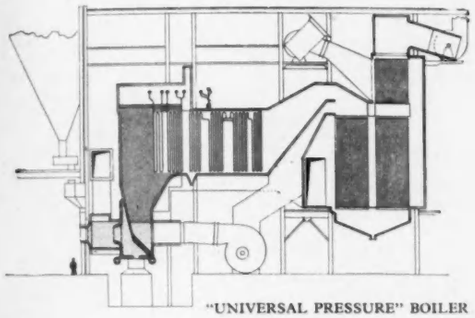
BROOM & WADE LTD., P.O. BOX NO.7, HIGH WYCOMBE, ENGLAND Telephone : High Wycombe 1630 (10 lines) Telegrams : " Broom " High Wycombe

384 565

3 major advances in modern power generation



CYCLONE FIRING


"UNIVERSAL PRESSURE" BOILER

The history of electrical power generation is closely bound up with that of steam engineering and the major advances leading to more efficient, economical and reliable steam power generation, using increasingly low-grade, variable fuels, have been largely due to new developments in steam-raising plant and techniques, in which Babcock & Wilcox have continually led the way. Recent examples are the 'Cyclone' furnace and steam-generation at supercritical pressures, both of the highest importance in the more efficient use of 'conventional' fuels; and, as we move into the age of nuclear power generation, Babcock & Wilcox are again in the forefront with the design and manufacture of highly specialized steam-raising plant for the new atomic power stations.

CYCLONE FIRING

The revolutionary Cyclone furnace, burning even low-grade coals at high combustion rates with low excess-air and exceptionally high ash-recovery is now fully established as one of the most efficient means of firing large boilers, and offers outstanding operating advantages. Babcock & Wilcox Ltd., have under construction and on order a number of Cyclone-fired boilers for both power station and large industrial installations. Ask for Publication 1508/2.

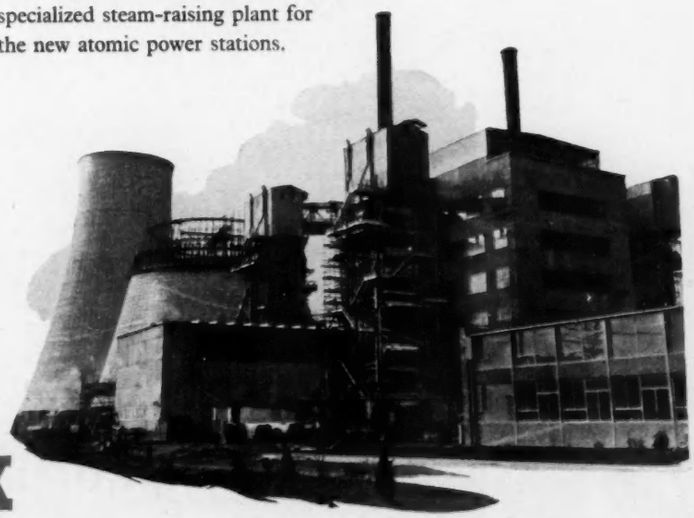
STEAM GENERATION AT SUPERCRITICAL PRESSURES

New Babcock developments include the "Universal pressure" boiler which is a 'once through' unit capable of large scale steam generation at pressures extending into the supercritical zone, i.e., to pressures above 3206 lb./sq. in., at which water, on reaching the boiling point, passes directly into steam without change of volume.
Using such plant, central station overall thermal efficiencies are expected of the order of 40%.

STEAM-GENERATING TOWERS FOR CALDER HALL

The fusion-welded, 80 feet high by 17 feet diameter steam-generating towers already manufactured by Babcock & Wilcox Ltd., for the Calder Hall atomic power station, with their complex multiloop banks of stud-tube heat-exchangers, represent a venture into a highly specialized branch of steam-generation in which the Company has been able to apply its existing experience and facilities to the design and manufacture of new and special forms of equipment.

★ The Company has subsequently received orders approximating £6,000,000 in value for the manufacture of another 24 similar towers for the Calder Hall and Chapelcross atomic power stations.


Calder Hall atomic power station under construction, showing some of the Babcock steam-generating towers

Babcock

BABCOCK & WILCOX LIMITED, BABCOCK HOUSE, FARRINGDON STREET, LONDON, E.C.4

G

OPERATION CLEANLINESS

Supplying clean air to the most stringent, or the most modest, specification, is a major part* of our business. For every need—medical, scientific, industrial, commercial, domestic—we can supply the right type of filter from our very wide range (a selection of which is listed). The combined experience and resources of ACI and our associates, American Air Filter Co. Inc., have produced the most comprehensive range of air filtering equipment available from any one single source. That experience and those resources are yours—in full; why not get in touch with our nearest branch.

* *We are specialists in every form of air treatment —and in harnessing air to work for industry.*

PL-24
A dry filter employing an inexpensive throw-away medium. Compact; easy to maintain.

ELECTRO-PL
A dry type electronic precipitator of similar constructional design to the PL-24.

ELECTRO-KLEAN
A compact electronic filter for the smaller installation.

MULTI-DUTY
A positive self-cleaning viscous impingement filter with very high efficiency.

AIRMAT
An industrial dust collector employing various types of filtering media to suit conditions.

DUSTRAP
A complete range of throw-away and cleanable filters in standard size frames.

LFO
A viscous impingement type filter for manual cleaning.

CYCOIL
A compact filter combining centrifugal separation and viscous impingement, specially developed for compressed air and large diesel engines.

ACI LTD

Air Control Installations Limited

Ruislip, Middlesex. Ruislip 4066 (8 lines)

London	Birmingham	Manchester	Newcastle	Glasgow
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1306	1165 & 1367	0679 & 0670	23046	2923

AAF

save capital costs with

BICC

ALUMINIUM CONDUCTOR CABLES

With aluminium less than HALF THE PRICE OF COPPER, savings in cable costs of up to 40% can be effected by the substitution of aluminium conductors. BICC Aluminium Conductor Cables can be supplied in a wide range of types and sizes with either lead or aluminium sheaths. The BICC Technical Advisory Service is always ready to give you the benefit of its knowledge and experience in making the most suitable choice of cable.

BRITISH INSULATED CALLENDER'S CABLES LIMITED
21 Bloomsbury Street, London, W.C.1

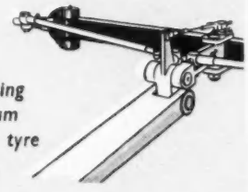
BI Callender's

So many features ...

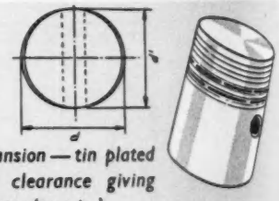
make ARPIC the world's most economical Air Compressor!

Lubromatic Clutch—hydraulically operated through a simple hand control—cannot slip or overheat—automatically disengages if oil pressure falls.

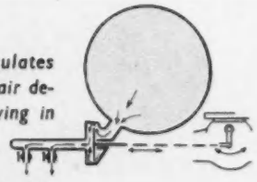
Automotive type steering with Ackerman linkage, giving safe towing at maximum speeds and reducing tyre wear to the minimum.



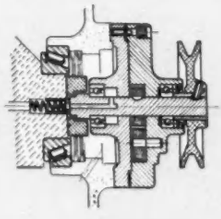
Ovalised pistons for uniform expansion — tin plated for reduced clearance giving safer and better 'run in.'



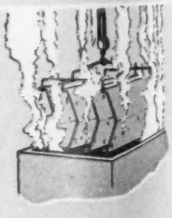
Fuelmiser — regulates engine speed to air demand — 30% saving in fuel consumption —reduces wasteful unloader operation.



Permanently primed, positive displacement gear type oil pump — high pressure lubrication including small ends at all running speeds.



Body parts bonderised for protection against rust — spray finished in oil and weather resistant high gloss enamel.



Feature for feature no other compressor can match the ARPIC

Extensive research and study have gone into the design, choice of materials and method of construction of each machine. Every component part is engineered to specification and thoroughly tested for maximum efficiency under all working and climatic conditions. In addition, a world-wide servicing organisation ensures that reliable and economical performance is maintained for the maximum length of time. Write today for details of the ARPIC range and of the ARPIC agent in your area.

ARPIC ENGINEERING, QUEENSLIE ESTATE, GLASGOW, E.3, SCOTLAND · CHAUSSEE dE BOOM, WILRIJK, ANTWERP, BELGIUM

WEINGARTEN

TRANSFER PRESSES

INTERNATIONAL MACHINE TOOL EXHIBITION 1956

- Rigid closed-type frame.
- Drive through multi plate clutch.
- Hand or electro-pneumatic control.
- Accurate transfer between stations.
- Provision for feeding coil or stock strip.
- Automatic vacuum pick-up for feeding blanks.
- Adjustable pneumatic die cushions available.

This machine is an excellent example of the well-engineered presses produced by Weingarten. It meets the need for fast, economical, mass production of stamped and drawn pressings used in the light engineering and allied industries.

The press is essentially an automatic machine for flow production, producing a finished part at each working stroke, from strip or prepared blanks. Drive and operation are extremely smooth and fine controls can be employed in forward or reverse directions for delicate tool setting.

These transfer presses are available in a wide range of capacities, each with 5 to 10 stations as required. For economy of material a stagger feed device may be employed on the smaller machines up to 30 tons pressure.

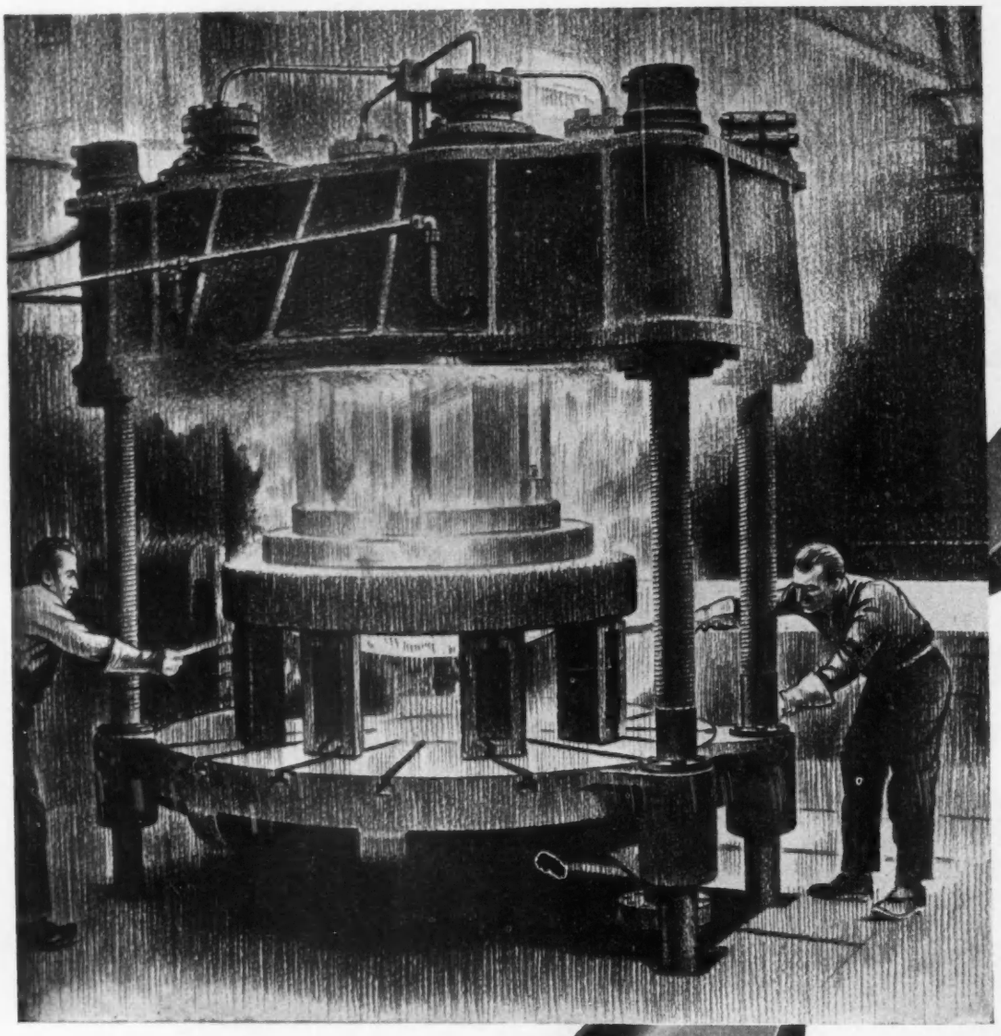
Wickman

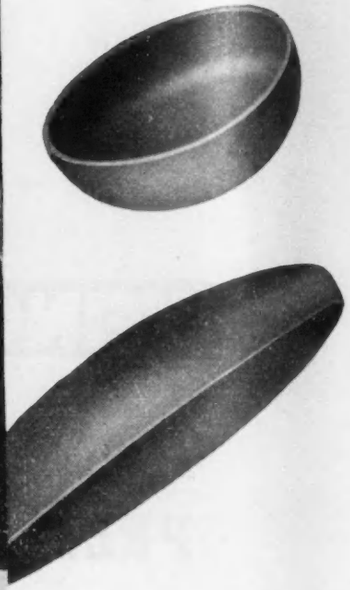
WICKMAN LIMITED

FACTORED MACHINE TOOL DIVISION · FLETCHAMSTEAD HIGHWAY · COVENTRY

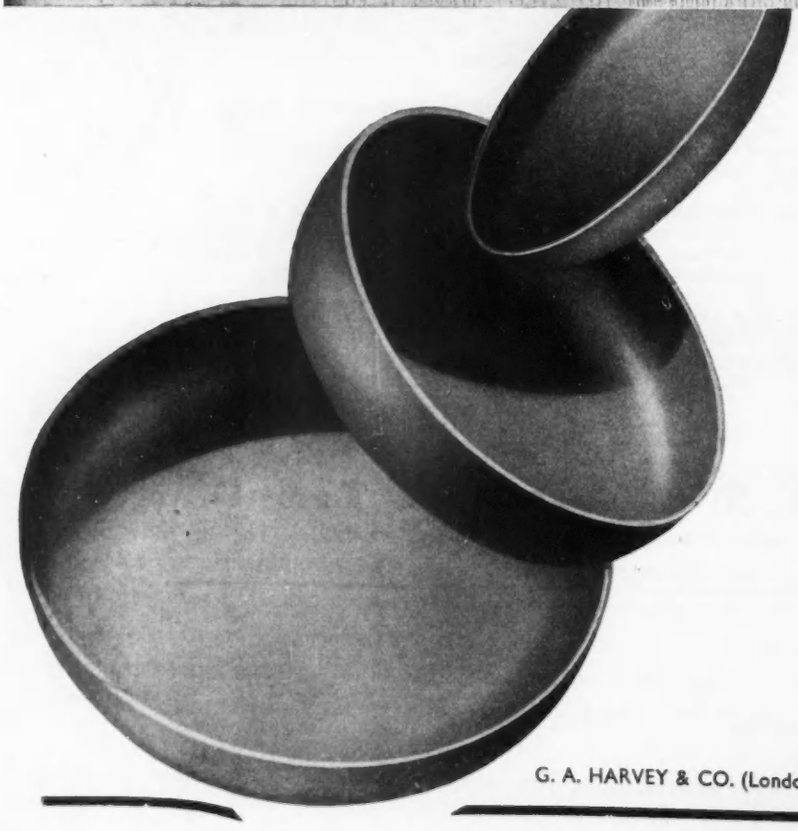
Telephone : Coventry 40351

429 F71





DISHED and FLANGED ENDS



Fabrication of pressure vessels may be greatly facilitated by drawing upon Harvey resources for the production of die-pressed Dished and Flanged Ends.

Capacities range from 6 in. to 9 ft. diameter. Edges are prepared for welding or riveting if desired.

STOCK SIZES: Ends pressed from Boiler Quality or Ship Quality Mild Steel up to ½ in. thickness, in most sizes up to 7 ft. diameter, are normally available from stock.

SEMI-ELLIPSOIDAL HEADS can be produced on the Rotarpress; diameters 5 ft. to 15 ft.; thicknesses ⅜ in. to 4 in.

For details, please ask for List No. EG881.

Harvey

G. A. HARVEY & CO. (London) Ltd., Woolwich Rd., London, S.E.7. Phone : GREenwich 3232 (22 lines)

ALLOY STEEL CASTINGS & FORGINGS

Hadfields produce castings and forgings for aircraft in a wide range of alloy steels. Their foundries, which comprise a large conventional foundry, precision casting and shell moulding units, are A.I.D. approved for castings to D.T.D. 666 and 705.

Class I components include sand castings, precision castings by the lost wax and shell moulding processes, turbine disc and compressor wheel forgings, etc.

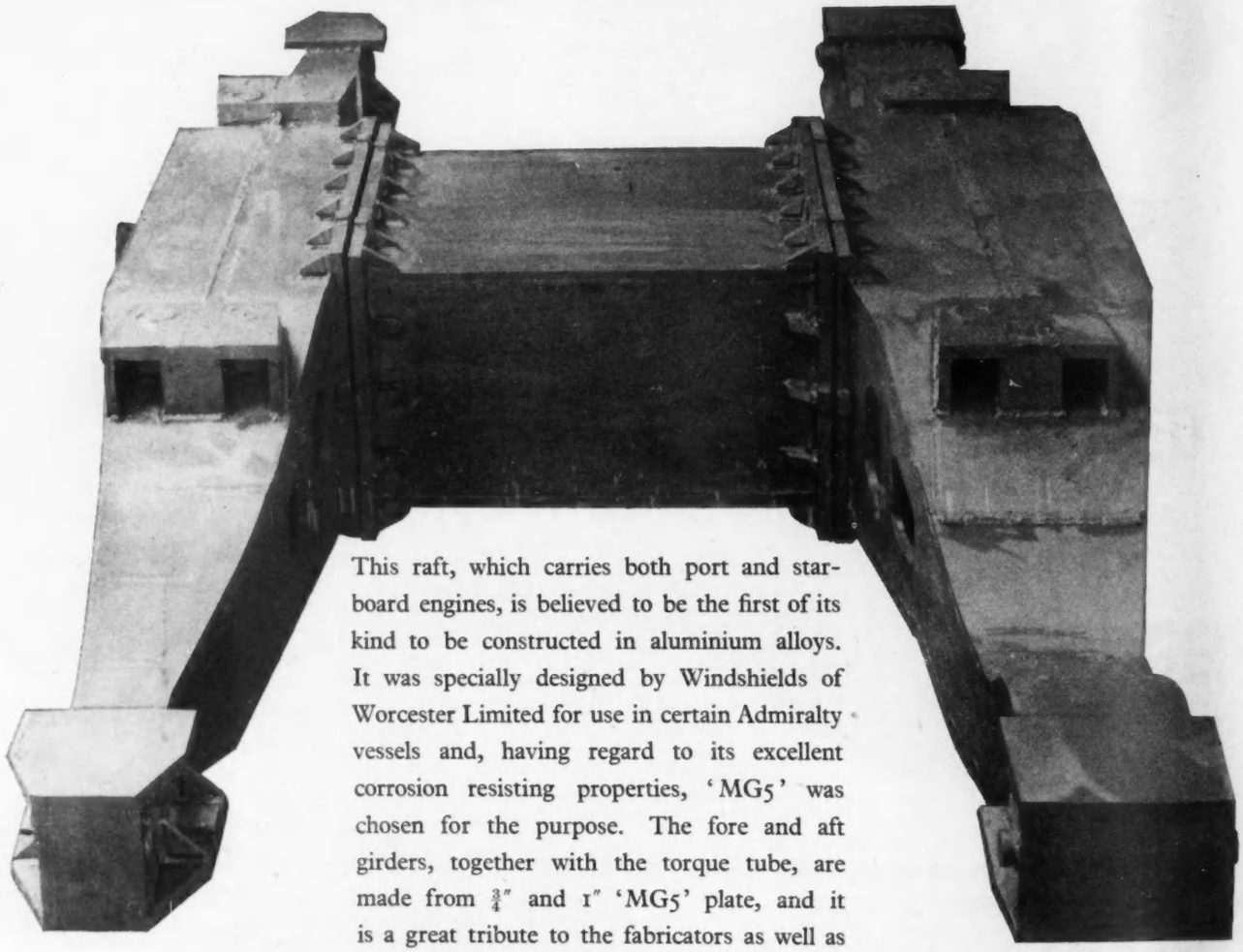
Compressor wheel for 'Avon' engine, by courtesy of Messrs. Rolls-Royce, Ltd.

HADFIELDS
SHEFFIELD

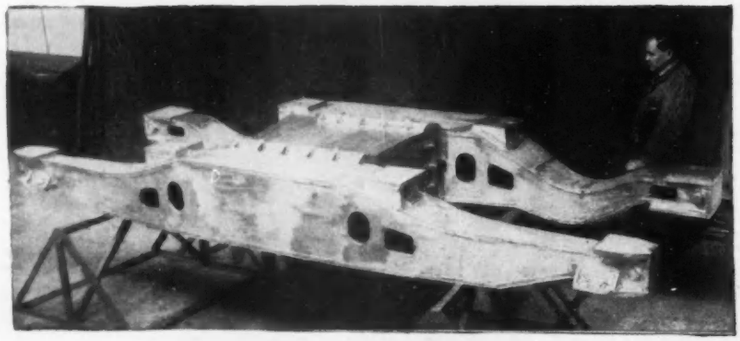
HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

Only one ton of 'MG5' carries two marine engines

REGD. TRADE MARK



This raft, which carries both port and starboard engines, is believed to be the first of its kind to be constructed in aluminium alloys. It was specially designed by Windshields of Worcester Limited for use in certain Admiralty vessels and, having regard to its excellent corrosion resisting properties, 'MG5' was chosen for the purpose. The fore and aft girders, together with the torque tube, are made from $\frac{3}{4}$" and 1" 'MG5' plate, and it is a great tribute to the fabricators as well as to the metal itself that the total weight of the entire raft is less than one ton.

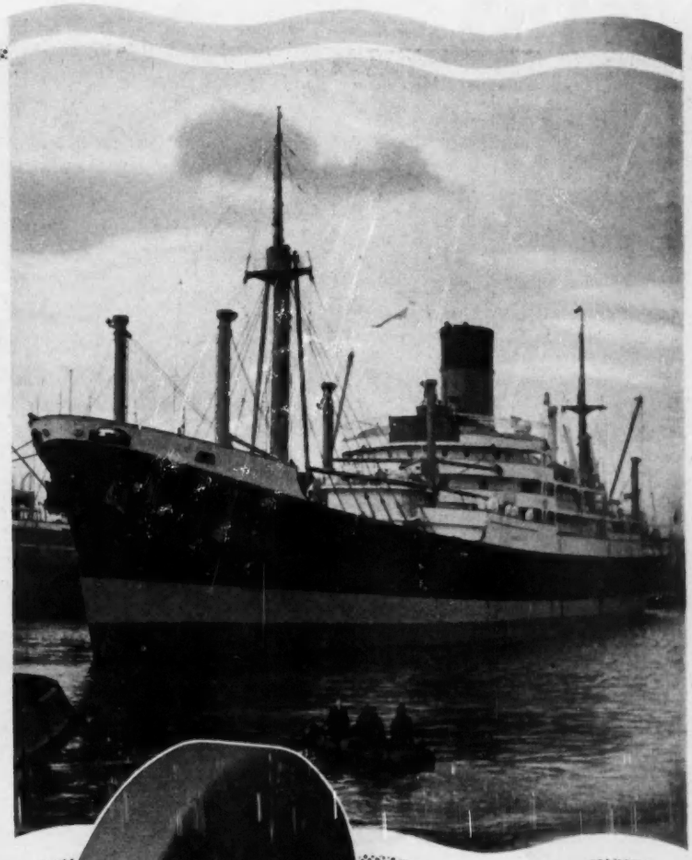


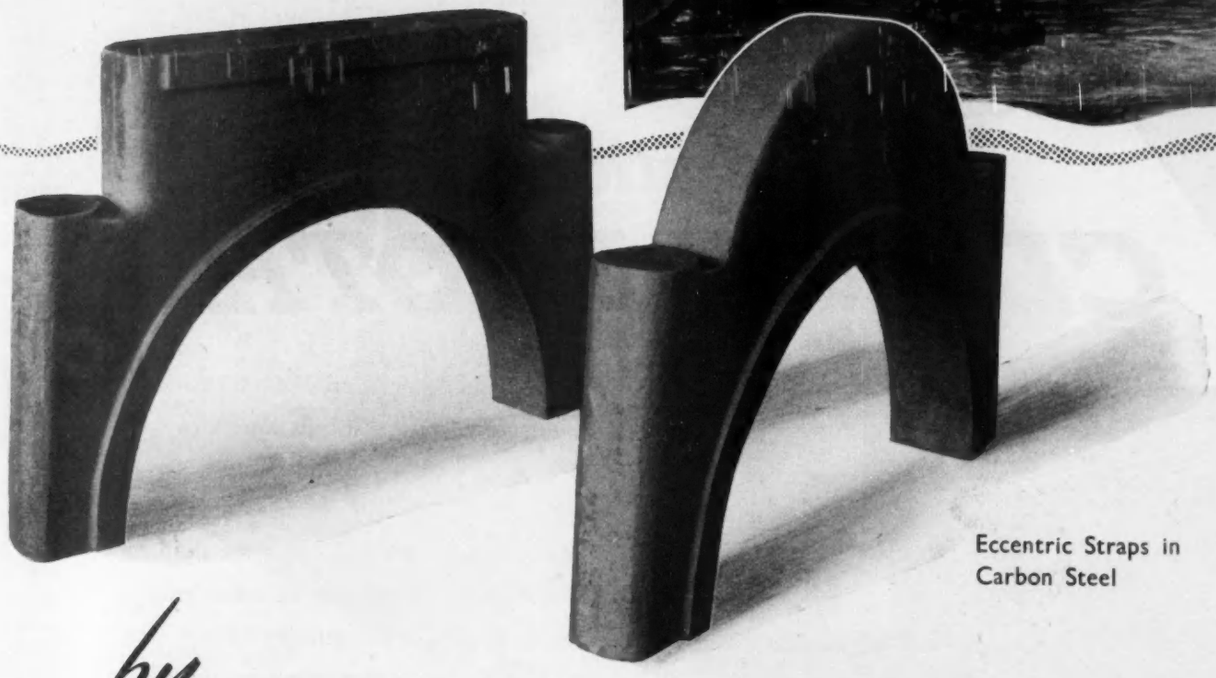
The unit was cut, shaped and assembled by Argon Arc, and Argonaut welding processes, and represents a particularly interesting example of a complex welded structure in aluminium alloys. The choice of 'MG5' for this application again confirms the modern trend towards aluminium alloys for marine use. 'MG5' has the strength to withstand heavy loads and impacts yet is light in weight. It is easily machined and resists corrosion.

JAMES BOOTH & COMPANY LTD · ARGYLE STREET WORKS BOOTH BIRMINGHAM **BIRMINGHAM 7**

Extrusions, large forgings, plate, sheet, strip, tubes and wire in brass and copper as well as light alloys

Steel Castings *for* Marine Diesel Engines





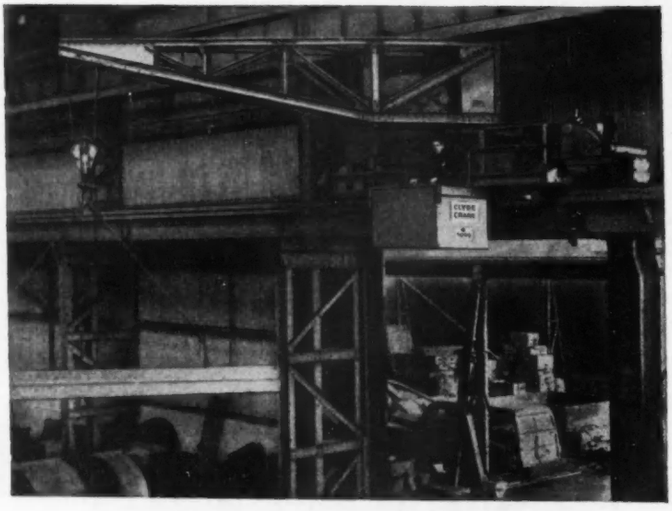
Eccentric Straps in Carbon Steel

by

FIRTH BROWN

THOS. FIRTH & JOHN BROWN LIMITED · SCUNTHORPE · ENGLAND

Combined Operation by CLYDE-BOOTH



This large machine shop uses cranes designed and manufactured by our Leeds and Mossend Works. To give first class handling facilities two 30 ton E.O.T. Cranes are provided while two 4-ton Wall Cranes, positioned each side of the shop handle the smaller loads. Both types of crane embody many special features representative of our long design and manufacturing experience in this field.

From a wide experience in designing and building all types of crane installations we should be pleased to submit proposals and designs to suit any requirements.

CLYDE BOOTH CRANES

CLYDE CRANE & BOOTH LTD

incorporating

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MOSSEND, Lanarkshire.
Telephone: Motherwell 354/5. Telegrams: "Clyde," Motherwell.

Joseph Booth & Bros.,
Union Crane Works, RODLEY, Leeds.
Telephone: Pudsey 3168. Telegrams: "Cranes," Rodley.

Industry's most versatile cranes

Jones Cranes can be supplied on pneumatics, crawlers or flat base and on lorry mounted or rail mounted chassis. Capacities from 15 cwt. to 7½ tons. Jibs of all types available, including cantilever.

EARLY DELIVERY

Hire purchase terms arranged

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SONS & COMPANY LTD.

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Designed, manufactured and exported by their Associates:-

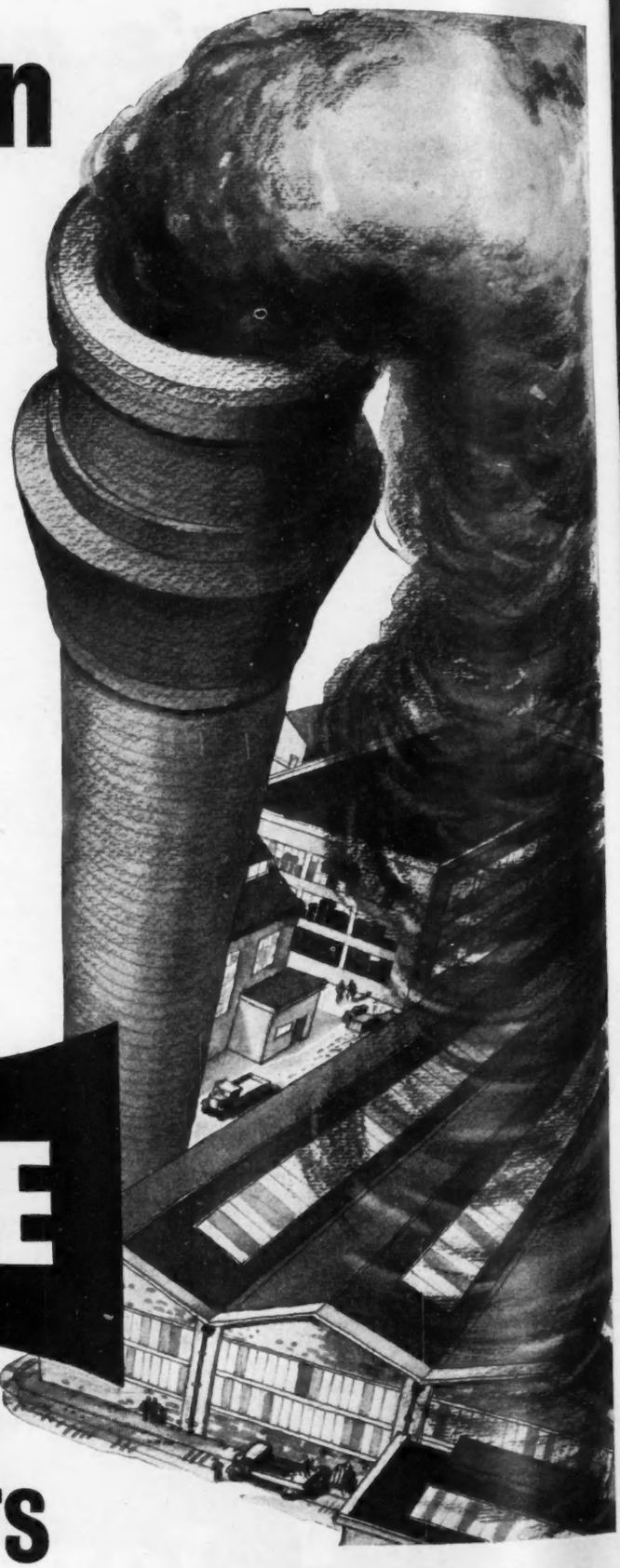
K & L STEELFOUNDERS & ENGINEERS LTD.
LETCHWORTH, HERTS.

THE 600 GROUP OF COMPANIES

Jones cranes

J100W

Protection against eroding fumes...



Evodyne C.R. Protective Paints give the utmost protection to iron and steel, wood, concrete, brickwork, etc. against atmospheric pollution, acids, alkalis, corrosive gases and salt water. They will also serve better than any oil-bound paint to protect asbestos cement sheeting, concrete and plaster—*without special primers!* Endorsed by leading Authorities and Industrialists.

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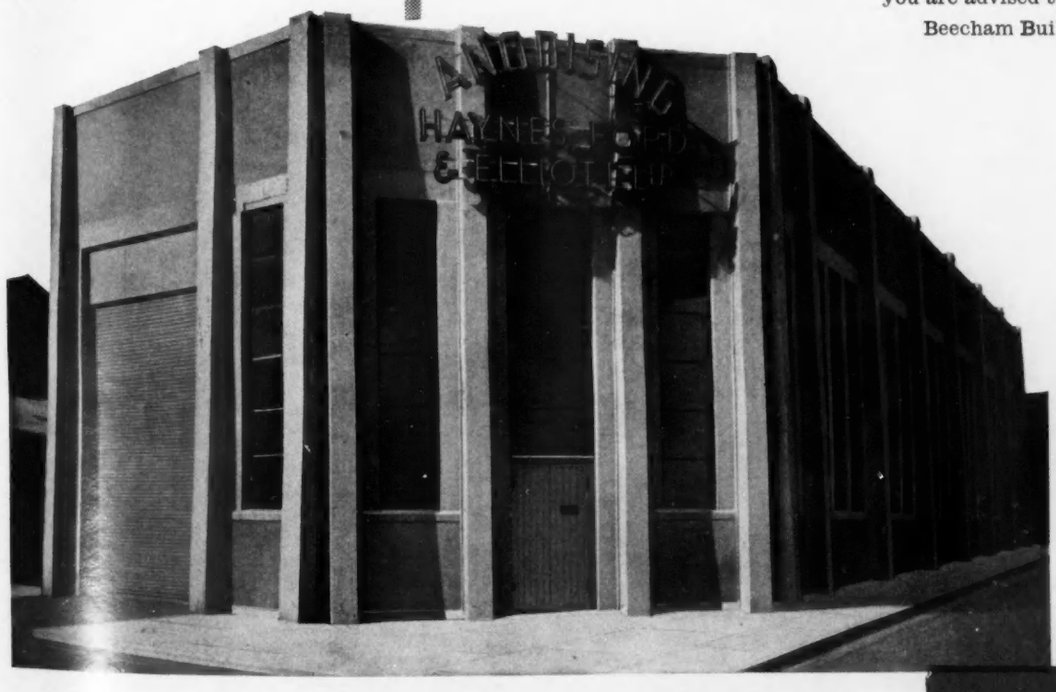

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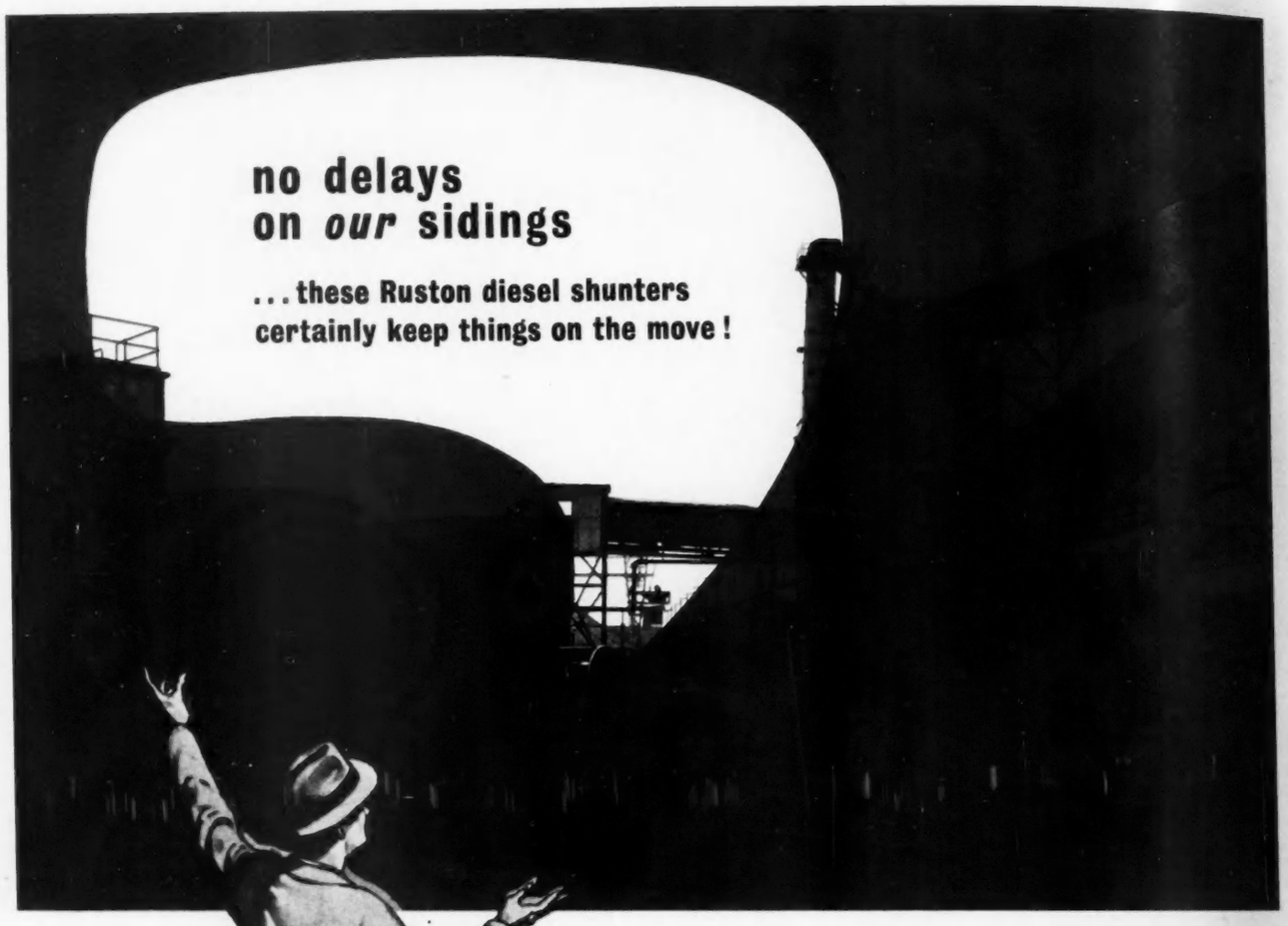

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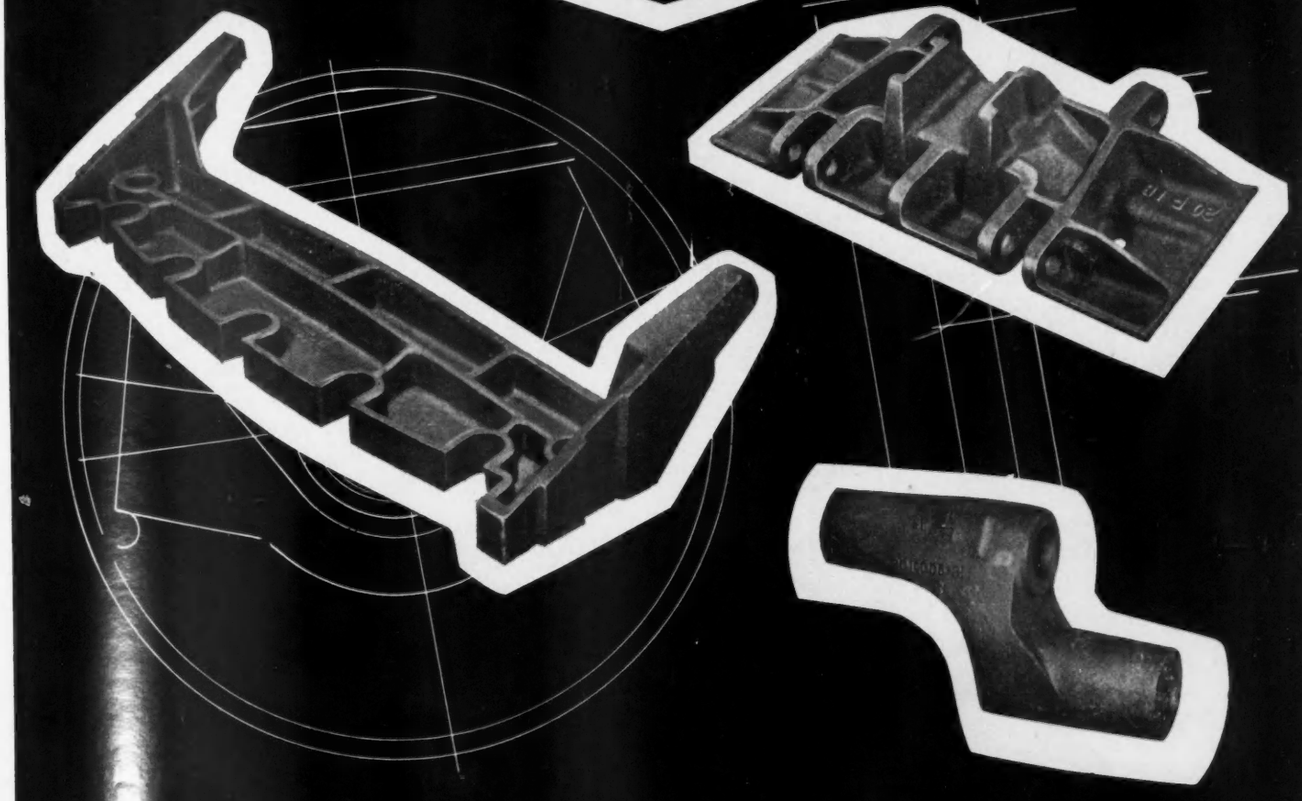

John Fowler & Co. (Leeds) Ltd.
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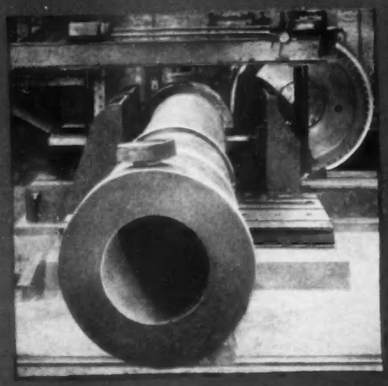
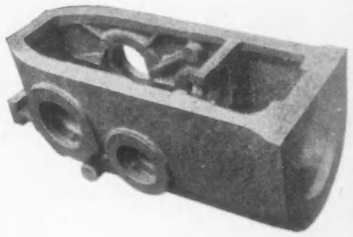
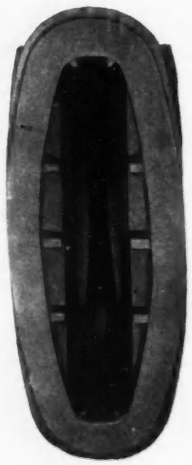
SPORTING & FOUNDRY LIFE

(huntin', shootin', castin')

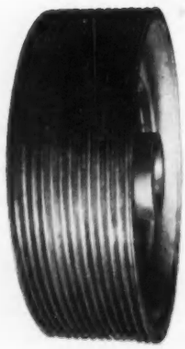


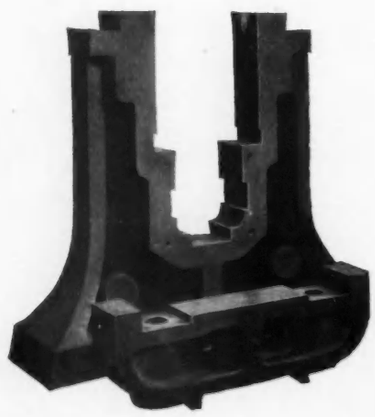


We are looking up the spout of a worthy piece of sporting artillery (above) which we once cast when our everyday fowling pieces were in dock because of powder fouling. The reason we tried using cannon was that if we were to have missed a phestoon of pheasants, or a pride of partridges when the cannon balls went up, we might have got a score of duck or a surfeit of lampreys when the balls came down. Actually, we never even sniped a snipe with it, and quails quailed at the sight of it. On one of our rotary planers we machined the ends as flush as our rich uncle.



The designer of the gearbox (above) said "Let 'em lubricate the gears with water; let 'em knock the gear lever in with a 28 lb. hammer; let 'em grind the gears like a barrel organ; this box is going to take it". We cast it in our foundry. It took it. Here are some castings (left) which we produced in moments of self-expression. Much thought and feeling went into their creation. They sold readily, and a customer telephoned to tell us that we had plenty of clues; it might have been curlews; we couldn't quite hear what he said for the sound of gunfire outside the offices.





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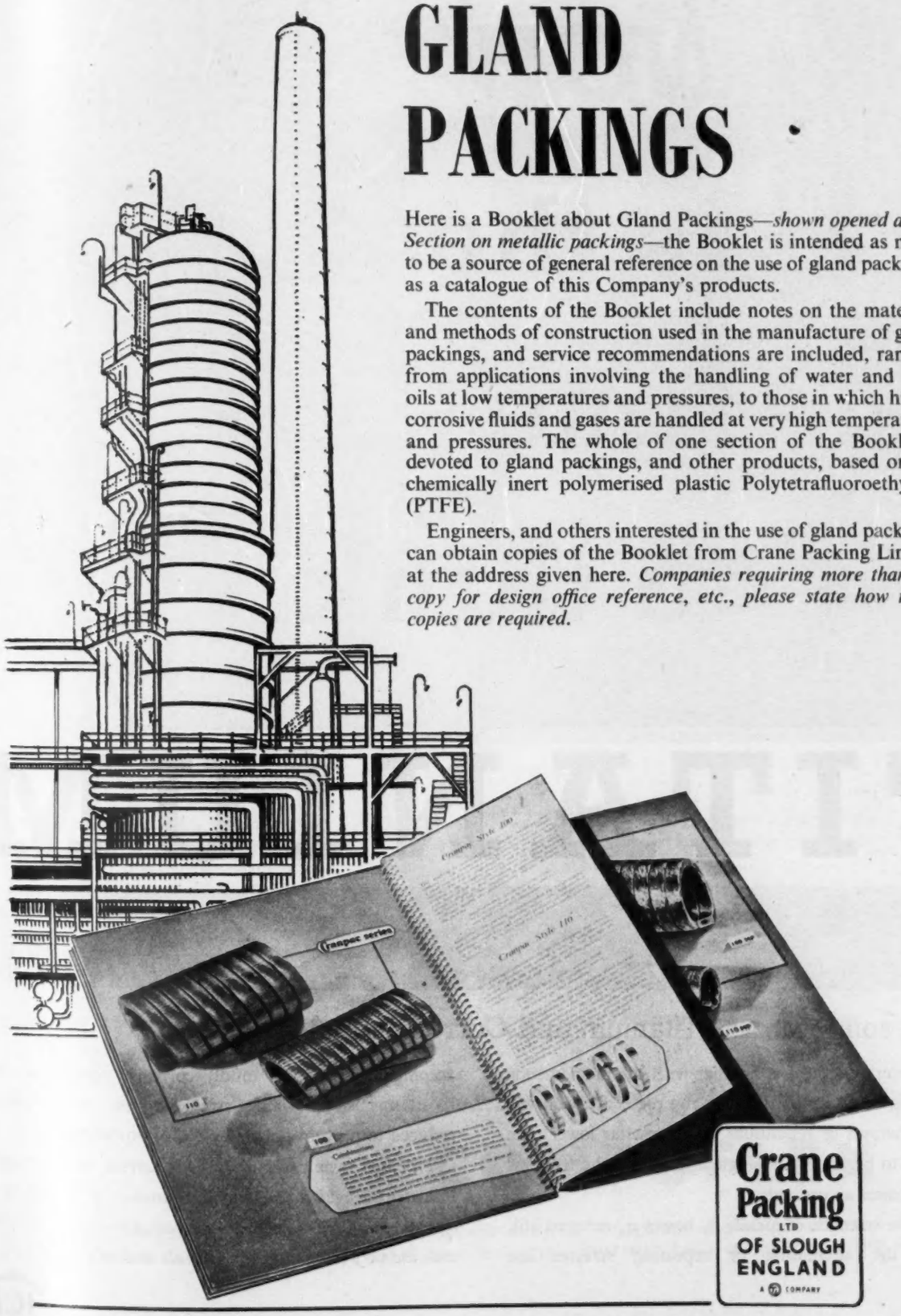
The contents of the Booklet include notes on the materials and methods of construction used in the manufacture of gland packings, and service recommendations are included, ranging from applications involving the handling of water and light oils at low temperatures and pressures, to those in which highly corrosive fluids and gases are handled at very high temperatures and pressures. The whole of one section of the Booklet is devoted to gland packings, and other products, based on the chemically inert polymerised plastic Polytetrafluoroethylene (PTFE).

Engineers, and others interested in the use of gland packings, can obtain copies of the Booklet from Crane Packing Limited at the address given here. *Companies requiring more than one copy for design office reference, etc., please state how many copies are required.*



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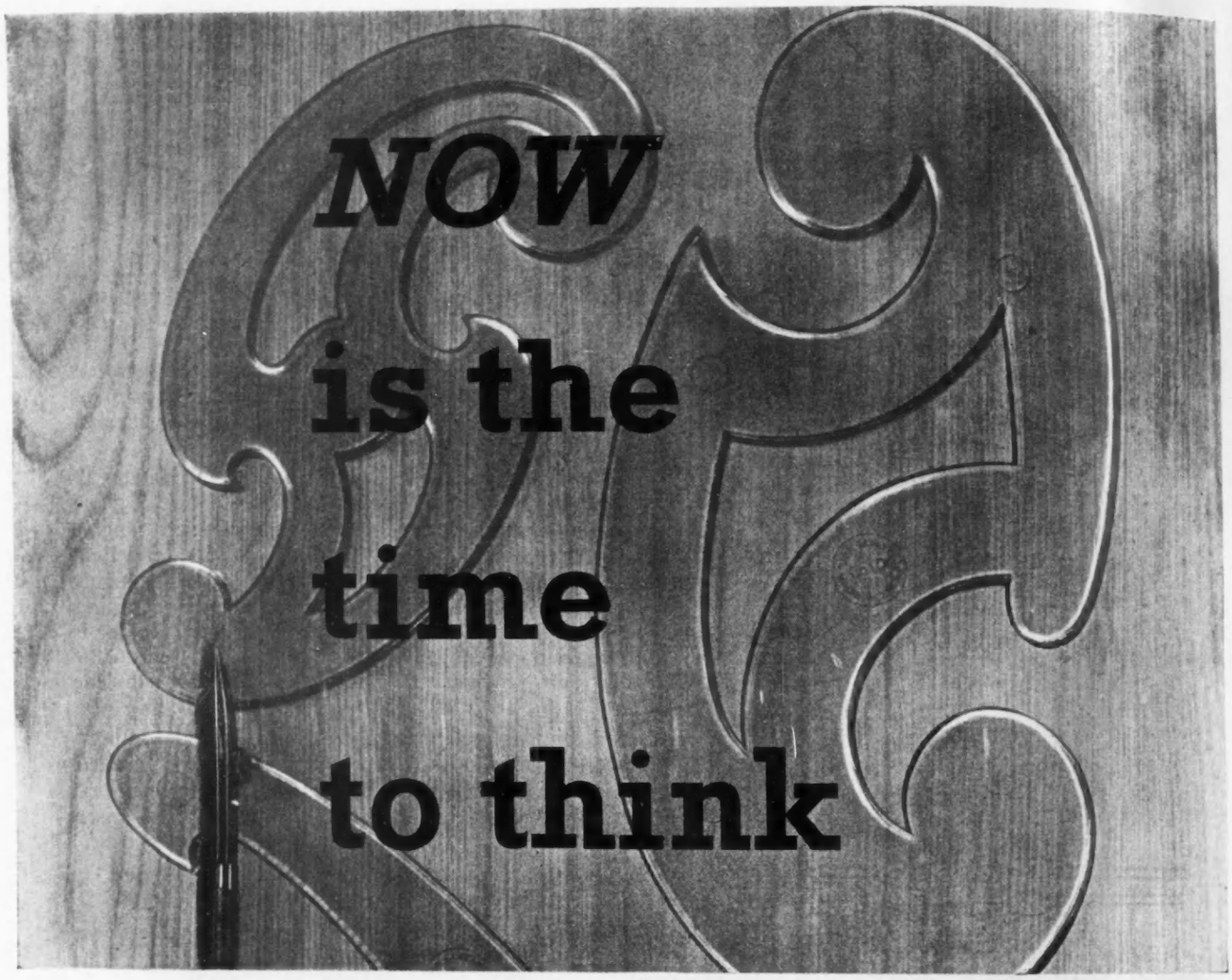

TITANIUM

TALKING POINTS No. 1... Titanium and Corrosion-Fatigue

Nowadays every engineer is familiar with the phenomenon of metal fatigue. Recognising that any piece of metal will fail by alternations or repetitions of a stress far lower than that needed to break it in a single application, he fixes his allowable stresses accordingly.

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DESIGN

Photo by courtesy of Pickfords

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costs

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come

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down

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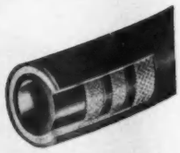
Goodyear hose is built to meet not only exact job specifications but also exact quality standards, set by years of research and experiment. These standards ensure that Goodyear hose combines maximum strength and flexibility with high resistance to wear.

WRAPPED PLY This type of Goodyear hose has layers of rubberised cotton fabric wound over a smooth-bore tube of high grade compounds and protected on the outside with a tough rubber covering. Made in 60 foot lengths.



BRAIDED CORD Braided Cord Hose embodies strong cord layers braided over a lining of high grade compounds and with a smooth, uniform bore. Made with one, two, or three braids as operating conditions demand. A heavy cover of tough rubber provides exceptional resistance to wear. Mandrel built in lengths of 60 feet.

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ENGINEERING

An Illustrated Weekly Journal

Vol. 181 No. 4707 MAY 25, 1956

Leading Article

Bigger Business 385

Plain Words 386

Weekly Survey 389

Principal Articles

Joseph Stenson and the Britannia Bridge: Some Contemporary Impressions 386
Elections in the A.E.U. 388
The Formability of Aluminium Alloys 393
International Atomic Co-operation 397
Measuring the Flow of Heat: Thermo-Junction Discs 397
Instruments for Ocean Research: The National Institute of Oceanography's Techniques 398
Crankcase Explosions: Causes and Prevention 401
Institution of Naval Architects Spring Meeting: Stability of Ships 401
Grinding Connecting-Rod and Cap Sides: Special Work-Carrier on Duplex Grinder 402
Light Gas Turbine: Versatile Auxiliary Power Plant 405
Royal Society Conversazione: Applied Electron Microscopy 406
Consolidation of Ballast: Experience with Mechanical Methods 407
Track Life Studied in Laboratory: Train Simulator Built 407
Prestressing a Steel Girder: Renewal of a Corroded Railway Bridge 408
Atomic Review 409
Fixed-Speed Wind Motor: Variable-Pitch Blade Tips 410
Producing Steel Reinforcement Fabric: A Modified Standard Machine for Unskilled Labour 410
Sand Pump Dredger for Indonesia 411
Mechanical Handling: 4—Mast and Marshalling Equipment 413
A Bright Nickel Plating Process 414

Book Reviews

Boundary Layer Theory 403

New Books and Trade Publications 404

Notes

Electrical Association for Women 387
Electrical Research: ERA Investigations 388
I.E.E. Annual Report 388
Research Scholarship in Foundry Work 396
New Silver Rivet Contacts 406
"Rivers of Life": Film 411

Notices of Meetings 410

Forthcoming Exhibitions and Conferences 412

In Parliament 415

The Human Element 416

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Published every Friday by Engineering Limited
35 & 36 *Bedford Street, Strand, London, W.C.2*
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

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Subscription rates for 12 *months, Inland and Abroad* £5 5*s*. *Canada* £5 5*s*. *Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s*. 3*d*.)

BIGGER BUSINESS

THERE are signs that we are entering an age of passive protest. The protest is that of the individual before the overwhelming growth of almost every institution in society and it is passive because there is nobody to blame, no one on whom responsibility can be pinned, no relevant plan, popular movement or cause to be espoused. At present the protest is mainly confined to the young and particularly young novelists, and though Kingsley Amis, William Cooper, and their *confrères* may not themselves be typical, it is safe to assume that if their books are widely read then they reflect a mood that is fairly widespread. What form does their protest take? Their heroes seem to say "Run the world as you like but count me out"; they are uncommitted in the broadest sense, as if the only way to retain human dignity in a world of mass production, mass communications, mass enterprises, mass entertainments, mass politics, and mass everything else were to remain aloof; personal integrity is everything, even (or especially) to the point of rudeness, and "phonyness" must be avoided at all costs. Having only a political Hobson's choice they feel powerless to affect the course of events and make no effort to do so; they are not prepared to share the common guilt when our leaders ride rough-shod over foreigners or let off hydrogen bombs without asking. To treat this protest seriously—though solemnity is the last thing these heroes could stomach—the following questions might be considered: is the yeast-like growth of institutions inevitable? And, if it is, is it entirely to be deplored? And in any case how can we accommodate ourselves and the resulting megalithic society to each other?

Evidence that large institutions, whether in business, politics or leisure, are here to stay is given in a booklet entitled "The Problem of Bigness," published by the London Press Exchange, in which Professor P. Sargant Florence suggests that economic pressure favours bigger businesses, both because large plants can permit long fully occupied production runs, close proximity of consecutive processes and the high capital cost of automation; and also because to avoid the risk of failing fashions, it is advisable to make several different products in the same factory.

But is bigness necessarily a bad thing? Before this can be answered, it is essential to understand what people expect from life. Unfortunately, few people ever consciously consider what it is they want beyond the serviceman's dream of "a nice little country pub"; and the corporate hope for the future is even more difficult to resolve. However, some minimum requirements might reasonably be listed. There are for example the basic needs—house, warmth, food and clothing; a few inessential aids and luxuries; and adequate leisure.

Are any of these conditions implicitly excluded by the expansion of our institutions? The answer must in general be no. True, the sense of identity can often be lost by people working in a large organisation, but this is only a problem of flexibility and communications—a subject which has yet to be adequately studied—and in any case the advent of automatic control techniques should dispense with the repetitive tasks which contribute so much towards this feeling. By proper use of encouragement systems, a man may come to feel that he has interests in common with the organisation to which he belongs.

What steps can be taken to reconcile ourselves to the inevitable new society? How can we tame the monster? We can no longer be satisfied with the glib definition that the function of industry is the creation of wealth; industry involves too many people to be simply that. To contradict President Coolidge, the business of people—Americans or otherwise—is not business but living. With large complex organisations planning is unavoidable, but people will only submit to planning in part of their lives. With the techniques soon to become available, this planned section may slowly be reduced. Industry would eventually be only incidental to our lives, and its efficiency would be measured by its inconspicuousness.

We tend to be sceptical about the possibility of changing the world—the young novelists seem to have given up entirely—but, after all, engineers have adapted physical nature by learning its laws, why cannot society be guided, also in accordance with natural laws? The man who devised the limited liability Acts was as much a progenitor of modern industrial civilisation as James Watt. Of course, it is valueless to impose repressive legislation on a society counter to its organic development; social ecology would cause new troubles to break out elsewhere, but it is surely not compatible with human dignity always to be "tossed hither by objective influences and thither by subjective emotions." Given the minimum requirements outlined above, steps can be taken to bring them about. Society can be studied scientifically with no less profit than can the mind. But if the frustration which has been foreseen is not dispelled, life in the future may be very uncomfortable. "Energy and the wish to be effective are beneficient if they can find the right outlet, and harmful if not—like steam, which can either drive the train or burst the boiler."

The Dinner Law: curve relating optimum number of speeches to the number of diners.

Plain Words

A few plain words on institution dinners would not be amiss. The arrangements for some of these dinners have been improved by experience over the years, but there are still a few which disappoint.

When the number of speeches is more than four, or especially if the speeches are long, boredom ensues. Consider a member who brings a guest. A kind of psychological complex develops between them. Both the member and his guest are embarrassed by the prospect of an evening's conviviality being whittled away by " platitudes in stained-glass attitudes," extracts from *Who's Who*, definitions from the *Oxford Dictionary*, references to productivity, automation, Her Majesty's Ministers, the need-to-pull-together, civil servants, the guests, the history of the institution, the I-musn't-talk-shop line, I-can't-end-without . . . . and so on. Embarrassed by the atmosphere which is developing, the guest at first pretends he has not noticed it. The member, anxious to be a sympathetic host, knows that his guest *has* noticed it. He endeavours to put his guest at ease by joking about the long speeches. The guest responds; he, too, makes a few joking comments, but he has to be discreet lest his disappointment is too obvious to his host. The chain reaction builds up, ending in a barely-suppressed babble at every table.

An important variable in what we might call the Dinner Law is the number of members plus guests. The higher the total the more necessary it seems to be to limit the number and duration of speeches. A small party will suffer much in silence, but in a large assembly those remote from the top table soon start talking among themselves. The Dinner Law is illustrated by the graph above. Its practical significance may be appreciated by noting that if, for a given dinner, the point corresponding to number of speeches and number of members plus guests is below the curve, the speakers will do all the speaking; if it is above the curve the members and guests will take over. The unknown quantity in the equation is, of course, the unpractised speaker; there is always a risk that he will speak for far too long. Such speakers seem to become deaf as soon as they stand on their feet; they are blissfully unaware of the uneasiness they are causing. We know: we once committed the same sin ourselves.

JOSEPH STENSON AND THE BRITANNIA BRIDGE

SOME CONTEMPORARY IMPRESSIONS

By I. M. F. Hooker and N. Dermott Hunt

Amongst the historical papers of Joseph Stenson her great-grandfather, Miss Hooker (one of the authors of this article), of Bristol, has found two of his printed pamphlets and a 16 page letter of particular interest to engineers.

In the pamphlets, the firm of Stenson and Company, Patent Iron Scrap Forge Works, Northampton, describe their patented corrugated bar iron and a welding hammer (Fig. 1).* The pamphlets, written by Joseph Stenson (Fig. 2), then head of the firm, describe these inventions, and are good examples of the direct factual advertising of the time.

Usually, nine plain-surfaced portions of a rough bar, cut into pieces, were placed one on another in a rectangular pile, heated in a furnace, and rolled out into a finished bar. " The cohesion between the various plain surfaces is seldom quite perfect, the finished bar retaining throughout the straight line of juncture; and if in forging Bar Iron, the tool happens to enter one of the joints, or between the edges of any two of the pieces of which the bar is composed, a cleavage or lamination is produced.

"To obviate this defect the Inventors employ in the manufacture of their Patent Iron, rough bars of a corrugated form; these bars are cut into pieces and the pieces placed one on the other, the corrugations of each portion corresponding with, and fitting into, the corrugations immediately above and below . . . " The top and bottom pieces of the pile of nine were corrugated on their inner, but plain on their outer surfaces. The pile was then subjected to heat and rolling. Offering more surfaces for welding and cohesion and being rid of any possible straight line of cleavage across the resultant bar, finished bar iron of much greater strength was asserted by the inventors.

Hitherto, the usual method of welding had been to " take the pile out of the furnace and draw it a considerable distance along the floor to the rolls. During this time, the air acting upon, and between, the plates composing the pile, produces an oxidation and a cooling of the iron, which renders the welding imperfect."

Stenson was one of the pioneers of the Victorian iron age; a Godly, literary, sturdy enthusiast for the inventive marvels of his time, particularly railways—" these *innovating* lines " —and bridge-building. His was the firm that made the wheels for the funeral carriage that bore the body of the Duke of Wellington in 1852. Some of the notable iron-masters were friends of his. He was a privileged guest at one of the great feats of engineering of the mid-nineteenth century. His letter,* dated October 12, 1849, describes this event to his " dear Son & Daughter." Being too long to reproduce here in full, some of the characteristic, genial, copious reflections have been omitted and some of the earlier details summarised. The later, eye-witness account of " the lifting of one of the monster tubes " of Robert Stephenson's Britannia Bridge at Conway is given in Stenson's own words.

" I must now tell you that I have been journeying into Wales . . . You must know that the railways of the North & West of England have been stretching out their iron finger-nails and picking holes in the ragged coats of the Welch mountains, & on one of these *innovating* lines— ' the Chester & Holyhead '—it was necessary to

* The pamphlets are undated, but were apparently published subsequent to 1851, since the first of the six patents granted to Joseph Stenson was No. 13883 of that year.

* A specimen page is shown in Fig. 3.

AA Reverberatory furnace in which iron is heated previous to being rolled into finished bars.

B Furnace door.

C Patent hammer, resting on catch *d*.

E Lifting rod, which is in constant motion, and provided with a catch for lifting the hammer by means of stud F.

G Stay which carries friction roller I; this roller is the fulcrum on which the edge of lifting rod E vibrates: the lifting rod is pressed up to the roller by means of spring J.

H Vertical stay from top of furnace to beam overhead, which carries driving pulley, levers, &c.

K Cast-iron block, about 12 in. square and 2 ft. high, and supporting an anvil, the face of which is level with the furnace heating-floor.

L Vertical lever, the lower end working in a joint, and the upper end made to vibrate when pushed back by sliding bolt O, and brought back to its place by spring P.

M Slide working between two guards, *m m*, and lifted by means of lever N.

When door B is raised, and a pile of iron brought out of the furnace on the anvil, slide M is lifted, and then pushed back by bolt O, by which catch *d* is also thrown back, and the hammer immediately falls on the pile as it is drawn from the mouth of the furnace, and strikes one, two, or more blows, as required, until slide M is allowed to fall below the action of the bolt O, when hammer C again rests upon catch *d* until the next pile is drawn.

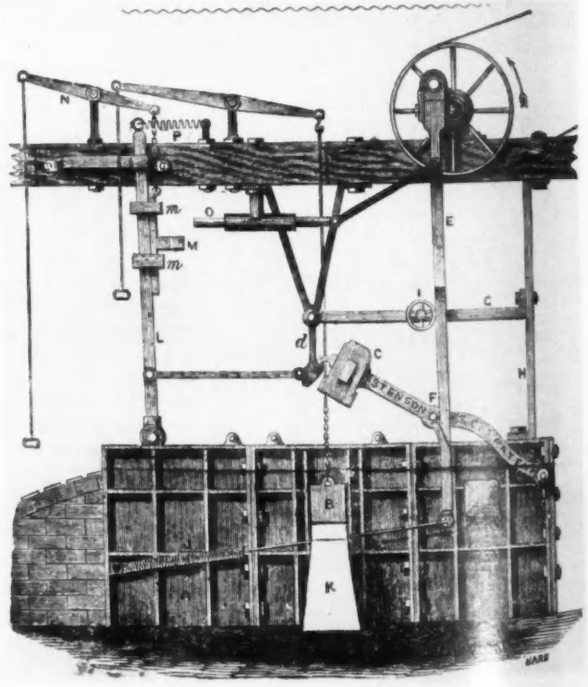

Fig. 1 Stenson & Co.'s patent welding ha[illegible]er.

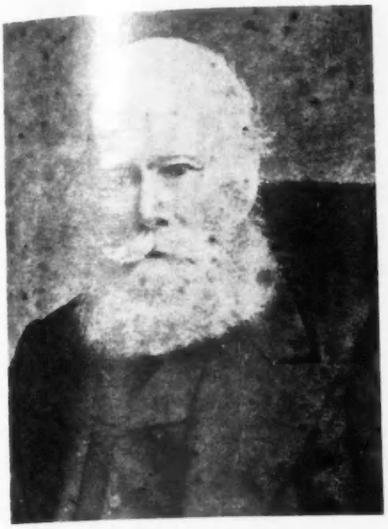

Fig. 2 Joseph Stenson of Luton and Northampton, head of Stenson and Co.'s Patent Iron Scrap Forge Works. He saw as a specially invited guest the first tube of Robert Stephenson's Britannia Bridge being lifted into place.

erect a bridge over the river at Conway." Despite public disbelief in the possibility of such an achievement, it was effected by two iron tubes, carrying the railway lines over the river to the more dangerous interruption ahead. " . . . at 16 miles beyond Conway is a wide and rugged bottomed branch of the sea, dividing the Island of Anglesey from the main land—at this spot, & near the village of *Menai*, is the famous chain bridge, built by Telford, who was also the Engineer of the great mail road to Holyhead—This chain suspension Bridge is indeed a noble work; the suspension bridge over the Thames at Hungerford Markett will give you a *small* idea of its structure and grandeur! Exactly one mile from this, and over the same water, is now in progress the greatest work ever executed by *wonderful man*! It is the 'Britannia Bridge' intended as a continuation of the same railway (just mentioned) . . . the line now unbroken except in this *one* spot, from London to Holyhead.

"You must now understand that my Friend Mr. Amos of the firm Easton & Amos of London—sent me an invitation to see the lifting of one of the monster tubes of this bridge. Mr. Amos is one of the Superintendents of the work and has made all the chains and hydraulic press &c.—with the pumps & steam engines for raising the tubes into their places, on the huge stone Towers now ready for their reception—a letter from him on Saturday evening reach'd me on Sunday morning! (Steam again!) & after going to Chapell on Sunday evening as a good Christian should do, & getting a good supper as we all of us like to do, I went and our George with me, —to see the lifting of the Tube.

"We left here (*Northampton*) by the 11 p.m. down mail, via Rugby, Stafford, & Chester—then after rushing through the Conway tube which we saw, as also the fine old ruins of the frowning Castle above it,—by . . . moonlight . . . at about 4 a.m.—we went on to Bangor—16 miles, where, leaving 'the wonderfull Crocodile' (*the train*) we . . . walked over the hills . . . for two miles, to—'*the Bridge*.'

"A walk of *one* mile, however, brought us to the summitt[ed] a low range of hills, & from which we fir[st] saw the chain bridge of the great Telford, & a[lso] a view also of the greater work of the *greater* R[obt] Stephenson, a mile beyond it . . ." at sunrise. [We] went onward to the chain bridge . . . [men] and women were passing, as also cattle, [car]riages, & I felt the ponderous mass trembl[ing] beath their tread. All at once, however, my [me]ditations were disturbed by a boistrous shout of 'Holloa there! why, Stenson, my dear Fellow, what on earth brought *you* here so soon this morning?' 'Oh, (said I) only the tea-kettle (*the train*) which I left boiling at Bangor!'

"It was my friend Amos who, opening the door of his barouche, gave my hand one of those desperate squeezes so much dreaded by a sore finger, and off we went for 'the works' first calling however upon Mr. Clarke the resident engineer under Robt. Stephenson—to whom I was introduced—next into a boat, and off again over the boiling waters, which at certain stages of the tide, are here very rough, from the very craggy and rocky bottom, ...

"We sail'd to the foot of the great Britannia Tower, so call'd from being built on a rock in the centre of the river, bearing that title.

LIFTING THE "GREAT LION"

"Now I am in a quandary, for I have not the ability to describe this bridge, & I much regrett that the *great Lion*, itself must go undescribed: for I could not do even a moiety of justice to this grand and noble project,—Its massive Towers, of 200 feet in height—one of the ponderous tubes, already half way up to its destination, & the connecting chains already adjusted at each end, the steam up at the two engines (one in each Tower) all ready for another lift; & waiting only for the two in whose company I was;—for the word of command—I must just hint to you here, that the great tube on which I now stood; having walk'd along it from the Britannia to the opposite Tower, weighs about eighteen hundred tons! and the chains cross head hydraulic ram, & other appendages are two hundred tons more; making a gross weight of two Thousand tons!!

"After a few questions from Mr. Amos as to the state of preparations,—he waved his silk handkerchief from the tower & which was directly answered by Mr. Clarke from the other tower;—all being ready 'Give her a little steam—gently with her, go steady'—the engines were worked simultaneously, & after a few strokes, the increasing shrillness of the exhaust steam in the blast pipe, told, in unmistakeable language, that she began to feel the ponderous load; the tube was raised slowly and steadily through a height of six feet, this being the length of each sett of flat links in the lifting chains;—all was quiet, and the silence unbroken; save by the intermittent blasts of steam above, & the gurgling rush of the boiling waters below.

"The tube, I may add, which if reared up in St. Pauls Church Yard, would reach 107 feet above the Cross!—was raised in 45 minutes, & *could be done* in 15 minutes. After the lift, Messrs. Amos & Clarke invited me to breakfast; I almost fogett what we eat and drank but while memory endures, shall not forgett the effect of that glorious sight.—Mr. Amos took us through one of the tubes now lying along side of the water & ready to be floated off; from the immense platform of timber on which it is built; on looking through the tube the effect is strange & pleasing, & is the most perfect piece of perspective probably ever seen,—a long straight aisle where, however, the work in the long receding roof, & groined at the angles; are an exact counterpart of the floor, in what may be appropriately call'd the Cathedral of Vulcan! The long walk through the tube is rendered somewhat laborious by the numerous ribs of angle iron which stand up along & across the bottom to give the work extra stability; on these are rivetted short pieces of angle iron to which the longitudinal timbers for carrying the rails are to be secured.

"About fifteen hundred men are engaged on the work—700 at the masonry, & 800 at the iron work; & not the least part of the novelty is the long ranges of work-shops; containing the various machines for pu(n)ching, straightening, & cutting the iron plates; and also massive steam machinery for revitting the plates up together, many of which were invented purposely for this great work.

"Then come the long ranges of wood sheds containing what my friend graphically enough, termed 'pack-thread' being immense piles of cordage, including probably some two to three hundred tons of 12 Inch Cables,—used in conjunction with the eight great pontoons near at hand,—when floating the tubes to the foot of the towers.—After a deeply interesting survey, of which the above rough scetch will afford you but a faint outline;—we returned as far as Conway, & were delighted with the interesting old Castle in ruins, not the least to be noticed is that the great tubular bridge here rests with one end into the very foundation of the old Castle itself . . . . ."

There is just room at the bottom of the sixteenth (last page) of Mr. Stenson's letter for affectionate leave-taking. Surely it is less a parting than a bridging of the centuries of man's creative invention?

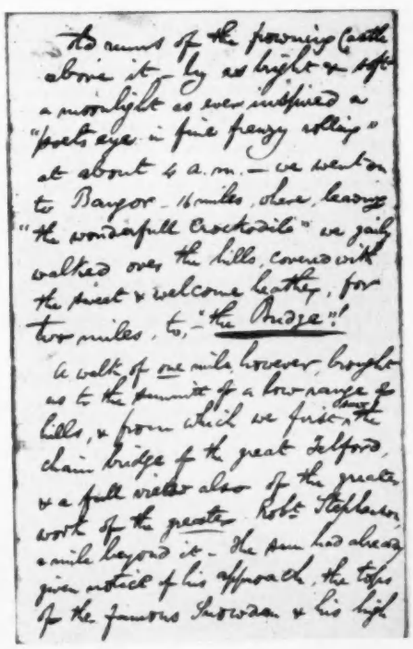

Fig. 3 Page 7 of Joseph Stenson's letter about his visit.

* * *

ELECTRICAL ASSOCIATION FOR WOMEN

New Headquarters

New headquarters for the Electrical Association for Women have been opened recently, at 25 Foubert's-place, London, W.1. Here members can see some of the best examples of modern domestic electrical equipment; and in the test kitchen new products submitted by the electrical manufacturers undergo a six-months trial under "field" conditions. In the case of cookers, the tests conform to British Standards Institution schedules, but generally speaking other apparatus will be tested under the conditions of normal domestic usage.

Although the E.A.W. receives a small subscription from the British Electrical and Allied Manufacturers' Association, the bulk of its financial support is derived from the subscriptions of its 12,000 members and it is in no way subsidised by the manufacturers. The purpose of the Association is educational but non-technical; to keep women informed of the latest electrical developments for the home. The professional examinations conducted by the Association, open only to those holding a domestic science diploma, are the recognised qualification throughout the United Kingdom for demonstrators of electrical domestic equipment.

ELECTIONS IN THE A.E.U.

The constitution of the A.E.U. (Amalgamated Engineering Union), one of the largest trade unions, is a strange combination of the American extreme separation of powers and the Russian arrangement of society. No doubt this is due to the circumstances of the two periods of historic change in this union: the formation in 1852 out of a number of old craft unions of the Amalgamated Society of Engineers, and the further amalgamation in 1920 which gave birth to the present A.E.U. The first amalgamation brought together a number of jealously separate unions and gave to the new Executive Council a greater power to exercise discipline over the branches, at a time when academic discussion of political constitutions was much concerned with the relation of the executive and the legislature. The second amalgamation took place while the trade union movement was still influenced by the recent Russian revolution, which at first appeared to give to a hierarchy of local and industrial soviets a degree of democratic power. A National Committee was at that time created, consisting of 52 members, indirectly elected in 26 divisions, which meets annually to determine policy. Officials and members of the Executive Council, whose job it is to carry out negotiations and administer the union during the course of the year, are not members of the Committee and only two or three of them attend it, so that there is a complete separation of the power to make policy from the responsibility of carrying it out. To complete the resemblance to the American constitution, there is an elected Final Appeal Court, charged with the duty of hearing appeals against Executive Council decisions and judging whether the union's rules have been carried out.

ORGANISATION

The union to-day has nearly a million members, including a number in branches in other commonwealth countries. In this country it is organised in over 2,000 branches which send representatives to about 270 district committees from whom the divisional committees which elect the National Committee are themselves elected. The President, who is the union's main national negotiating officer, and the general secretary, who has wide powers over head office administration and finances, are elected nationally and the Executive Council consists of seven members elected in regional divisions. All these officers, as well as national organisers, the regional organisers, the divisional organisers and the district secretaries are elected by ballot in the branches every three years. Even the delegates to the T.U.C. and the Labour Party, to which the Union is affiliated, are elected in this way. As a result there are always a number of elections in progress and it is this multiplicity which helps to create the apathy and low polls of which there has recently been so much complaint.

The shop stewards, who to-day play such a big part in the union's affairs at workshop level, although officially recognised for this purpose since the first World War, play no part in the policy making functions of the union, other than through their representation on the district committees. The various national committees and conferences of shop stewards which occur from time to time are unofficial and mostly Communist inspired. On the whole, although the A.E.U. to-day recruits men and women of every degree of skill, including the growing class of technicians, it is run by its skilled members, the majority of whom are among the most responsible members of society. The Union supports six members of Parliament, all from the ranks of skilled men who had held responsible positions, including one graduate engineer with managerial experience. The balance of political opinion of this group is near the centre and far removed from that sometimes expressed in resolutions of the National Committee. Two members held office in the Labour administration, Mr. Lee as Parliamentary Secretary to the Ministry of Labour, and Mr. Hobson as Assistant Postmaster General. Large numbers of union members throughout the country are members of local authorities, and they usually include several mayors and Council and committee chairmen.

CONTROL

Attention has recently been focussed on the A.E.U. constitution because of the series of elections at present in progress. Mr. Openshaw, the present President, is retiring under the age limit and the second ballot for his successor is taking place between Mr. Carron, at present representing Division 5, a very intelligent and responsible man, and Mr. Birch, the standard bearer of the London Communists. In Division 5 itself, which includes Sheffield, Derby, Lincoln, Rugby and Luton, the first ballot for Mr. Carron's successor is in progress between Mr. Hanley, Divisional Organiser of Lincoln, and Mr. Ullyat, the Communist Sheffield district secretary. A second ballot is also taking place for election of an Executive Councilman in Division 6, covering South Wales and the West Country. Owing also to the death of Mr. Ben Gardner who, for thirteen years, kept a tight rein on the Union's affairs as general secretary, nominations are now being received for this post. There seems to be a general view that the likeliest candidate is Mr. John Boyd, at present Executive Councilman from Scotland; but it is expected that Mr. Joe Scott, the Communist councilman in London, will also stand. In that case he will not be able to stand for re-election for the Executive Council and a very interesting contest should take place in this division which he has held for many years. At the present time there are only two Communists on the Executive Council, so that these elections are of great importance for the Union and the industry.

The strength of the Communists in the A.E.U. must not be judged from the often ill-thought-out resolutions passed by the National Committee, on which they have about one third of the members. Their strength lies more in a number of able candidates whom they have been able to put forward for responsible positions. Perhaps because of the insecurity and poor reward associated with these positions it has become increasingly difficult to get good non-Communist candidates to stand for them. In recent years the Union has lacked firm leadership at the top; although it must be admitted that the Union's constitution and the insecure position of its leading officers demand from a President or Councilman very considerable courage which needs to be backed by—what has often been lacking—a clear and straight-forward policy. In spite of the hampering effects of an obsolete constitution the power of the Executive Council, especially if it is prepared to appeal over the heads of the officers of the ill-attended branches direct to the members, could be very great. There is now a fair chance that a new and younger leadership may emerge whose ideas are more in keeping with actual conditions in the industry and with the changed economic and social status of their members.

* * *

ELECTRICAL RESEARCH

E.R.A. Investigations in 1955

The thirty-fifth annual report of the British Electrical and Allied Industries Research Association exemplifies the wide field of investigation that is being covered by that body. The actual programme of research, which is organised in 18 sections, covered such matters as insulation and dielectrics, switch and control gear, steam and wind power, the transmission of power at high voltages, surge phenomena, magnetic materials and rural electrification. It was pursued during the year under review on a slightly expanded scale, but "attack on some problems of interest to the industry [illegible] to be retarded, or even deferred, owing to [illegible] lack of sufficient means."

It is, however, satisfactory to note that the Government has realised the urgency of the problem of the flameproofness of electrical apparatus and the intrinsic safety of equipment and, as a result, has promised a contribution which will enable a more comprehensive programme of research on this subject to be put in hand. Financial assistance is also to be given by the oil and chemical industries. The electricity supply industry and the turbine, boiler and pipe manufacturers are similarly financing a programme on the behaviour of components under high pressure at high temperatures.

Research on insulation during the year disclosed a new form of instrinsic breakdown arising from instability in the electrostatic field. As a result, existing values of, and theories for, electric strength will need revision. The industrial significance of this discovery is not yet clear, but it occurred during research on the properties of irradiated dielectrics. Another result of this work was to show that irradiation enables polythene, for example, to retain discharge resistance to a much higher temperature.

It is also reported that the plant for extending the Steam Tables to 5,000 lb. per sq. in. and 1,400 deg. F. is almost ready. The enthalpy can be found to an accuracy of at least 0·2 per cent. and dissolved oxygen with ten times the previous accuracy. A new chromium-molybdenum alloy shows better oxidation resistance and creep properties at 1,150 deg. F. and interest is being shown by industry both in this and in titanium alloys in large turbo-alternators.

* * *

INSTITUTION OF ELECTRICAL ENGINEERS

Annual Report

The report of the Council of the Institution of Electrical Engineers for the year ended March 31, 1956, which was presented at the Annual General Meeting on May 17, is an interesting record of the useful work carried out by that body. The problems of increasing recruitment to the profession continued to receive attention since, as is recorded, the number of new entrants to a career in electrical engineering are still insufficient to meet the national need. The scheme of education announced by the Minister of Education in July, 1955, was received with some concern but, as the result of representations by the three senior engineering institutions, the scheme has since been modified.

A co-related matter of which mention is made is the investigation that has been undertaken into the causes of the fall in student membership. As a result, a number of measures—including a film and careers exhibitions—have been introduced and seem to have generated a satisfactory degree of interest. Moreover, those doing national service will enjoy a reduced rate of subscription, and the desirability of Corporate Members encouraging prospective members to join the Institution at an early age is emphasised.

The rate of increase in the membership of the Institution was well maintained during the year under review, the number of members elected being 1,978, compared with 2,200 in 1954-55. On April 1, 1956, there were 32,886 Corporate Members and Graduates on the register, representing 82·1 per cent. of the total of 40,038.

There seems to have been some falling off in the number of papers suitable for reading at meetings. In the case of the Supply Section this resulted in the introduction of discussions meetings and informal lectures, while in the Utilisation Section the customary Students' papers meetings could not be held as none of the contributions submitted was considered suitable. On the other hand, there appears to be little decrease in the numbers attending the meetings.

Weekly Survey

Cover Picture. *Vacuo-junctions are used with electrical instruments for the measurement of alternating current. The current applied raises the temperature of the heater, which is in thermal, but not electrical, contact with a thermocouple. The direct current potential created in the thermocouple is fed to a moving-coil galvanometer suitably calibrated. Relatively accurate measurements may thus be made with low power consumption and largely free from errors caused by variations of frequency and waveform. The junctions are enclosed in evacuated envelopes to prevent deterioration of the elements and welding of the heaters is necessary because the materials used do not lend themselves to soldering.*

* * *

Does Deflation Work?

It is now emerging which are to be the critical factors in reducing the head of steam on the industrial system if deflation is to work in 1956. There are signs enough that capital investment is still forging ahead. The machine tool order book has never looked better. Total new orders in February, for which figures have now been published, were £9·64 million, compared with £8·19 million in January (a rather longer month) and with £7·18 million in February 1955. Total orders in February stood at £104 million against £83 million at the same time last year. New home orders are increasing slightly faster than export orders—but the difference is not critical. A more critical fact is that the industry needs more skilled and semi-skilled labour. It is an industry which should be getting labour from a successful disinflationary policy, but this is not yet happening.

Where could the labour come from? Many industries hit by the credit squeeze (such as motor cars, motor cycles, bicycles, radio and T.V. sets, domestic appliances and textiles) are hanging grimly on to their core of key men, but it is these men that must be moved, at least in part, if exports and key capital industries are to go on expanding. Some of these industries—such as motor cars and domestic appliances—can see improved results which make them hold on and hope, though they have yet to find out if the spring recovery is going to develop, and for them the period up to the end of the calendar half-year should give the answer. The key factor is factory building. There are signs that although plans approved are still increasing, the numbers of new buildings actually started are faltering. If this faltering should become cumulative, deflation may get under way rapidly. Fewer new buildings started plus continued poor results in car sales at home and abroad could be a formidable combination.

* * *

Sir Henry Bessemer

The essence of the Bessemer process, the centenary of the introduction of which was celebrated last week during the annual general meeting of the Iron and Steel Institute, is that for the first time molten steel became available in quantity, making possible the great developments in steam and railway engineering, shipbuilding and other branches of construction, which were subsequently realised. Prior to 1856, broadly speaking, engineers could use, for bridges and other structures, cast iron or puddled iron, and for tools and other components, shear and crucible steels. Whereas, in the puddling and other hearth processes, a start was made with molten pig and the end product was plastic iron, Bessemer started with molten pig and finished with molten steel, and this in unlimited quantity.

In the course of a centenary lecture, entitled "Sir Henry Bessemer, 1813-1898," delivered in London before the Iron and Steel Institute, Mr. James Mitchell, C.B.E., a past-president of the Institute and a director of Stewarts and Lloyds Limited, observed that Lancashire boilermakers were making boilers from plates of Bessemer steel in 1859, that shipbuilders commenced to use the material in about 1863, and that the London and North Western Railway put down a Bessemer steelmaking plant for their own use at Crewe in 1869. Abroad, the adoption of the process was likewise rapid and far-reaching.

Mr. Mitchell mentioned the names of two men who, he said, should be remembered at this centenary time, namely, Göran Frederick Göransson and Robert Forester Mushet. The former demonstrated the success of the process when adapted to Swedish methods and materials, and the latter showed how to make iron ductile when hot, from red-short blown metal, by remelting it with spiegeleisen. We do not propose to outline again the controversy which followed Mushet's application for a patent on September 22, 1856, but it is pleasing to record, as Mr. Mitchell has done, that, years later, Bessemer not only came to Mushet's financial assistance when in monetary difficulties but cordially supported the proposal to award him the Bessemer Medal in 1876.

In conclusion, it is interesting to recall that there are several links between Sir Henry Bessemer and ENGINEERING. The late Mr. A. T. Hollingsworth, who with Dr. W. H. Maw and Mr. James Dredge, made us what we are to-day, was a relative of Sir Henry. Mrs. A. T. Hollingsworth (*née* Lottie Allen) was a niece of Lady Bessemer (*née* Ann Allen and daughter of Mr. Richard Allen of Amersham). Moreover, the autobiography which Mr. Hollingsworth and other friends persuaded Sir Henry to write, and which was extensively quoted by Mr. Mitchell in his lecture, was published by us in 1905.

* * *

Progress in Engineering and Steelmaking

When discussing future possible developments in steelmaking in his Presidential Address to the Iron and Steel Institute, delivered on May 16, Dr. H. H. Burton, C.B.E., of the English Steel Corporation Limited, Sheffield, said that in his opinion the acid open-hearth process was likely to continue for the manufacture of many special and alloy steels, and, particularly, large forgings. Many of the largest ingots made nowadays were intended for the manufacture of hollow forgings, such as seamless boiler drums and chemical reaction vessels. Hitherto, such ingots had been annealed, parted and trepanned to accommodate the forging mandrel, and ingots of 270 tons in weight had been made and utilised in this way in Great Britain. Obvious advantages would result if the ingots could be cast hollow in the first place and it was interesting to note that some progress had been made in this direction. One such hollow piece poured recently had a cast weight of 50 tons and measured 65 in. across the flats. It had a body length of 100 in. and a bore diameter of 20 in.

Indicating what seemed likely to be required in plant if the steel manufacturers were to meet the needs of engineering in the immediate future, Dr. Burton said that there was a need for improved forging plant in this country. Although Great Britain produced some of the world's largest forgings, the most powerful forging press in this country was one of 7,000 tons. Abroad there were presses ranging from 10,000 to 15,000 tons capacity, some of which were capable of dealing with forgings of larger sizes than had yet been made.

With reference to the heat-treatment of large forgings Dr. Burton put in a plea for the more intelligent use of pyrometric control. He said that the increased application of pyrometric instruments had caused the skill of furnace operators in judging both temperatures and uniformity in temperature to become a neglected art. Obviously, the remedy was to train the men in charge of important heat-treatment operations to be not only pyrometer readers, but also careful and accurate observers.

New Break-Through in Steam Turbine Efficiency

Startling proof of a belief long held by the British engineers engaged on steam turbine research has been provided by two United States companies, General Electric and Westinghouse. These have announced that each are building turbo-generators which will operate at super-critical pressures and temperatures and will soon be commissioned. The increase in efficiency of these turbo-generators is such—they are expected to raise the output of electricity from a ton of coal by 10 per cent. or more—that the advance is being described as a new break-through in steam turbine design. Actual figures quoted suggest an improvement in the electricity output from 1 ton of coal from 2,900 kWh (present best) to 3,450 kWh.

General Electric are installing a 125 MW set at a new power station of the American Gas and Electric Corporation at Philo, Ohio, which is designed to operate at an initial steam pressure of 4,500 p.s.i. (the highest pressure currently used is 2,400 p.s.i.) and at a temperature of 1,100 deg. F. The set will be in operation early next year. Westinghouse have designed a 325,000 MW set for the Philadelphia Electric Company which will operate at the super-critical pressure and temperature of 5,000 p.s.i. and 1,200 deg. F.

It has long been known that greater efficiencies could be obtained if steam turbines could operate above the critical point where steam and water have the same density. The difficulties of finding suitable materials to withstand the high temperatures and pressures have been the main obstacle to a similar advance in this country. The small amount of information released so far about the American sets indicates that super-alloys, based on chromium and nickel, with additions of small amounts of stabilisers such as columbium and molybdenum have been used for the turbine compressor buckets. The cost of the sets is said to be substantially higher than that of conventional designs owing to the high cost of the special alloys, and also because a number of additions have to be made to the plant. For example, a second stage of re-heat had to be added to reach the high temperature, new boiler feed pumps were found necessary to provide the higher pressure, as well as more feed water heaters and a special super-pressure turbine section. There is little doubt that such developments will take place in this country before long, but the difficulty of obtaining the required alloys is understood to have slowed down the progress of the few companies engaged in development work.

* * *

Heat from the Power House

Necessity is the mother of invention. When Richard Klinger started making water-levels for steam boilers he discovered that there were no suitable jointing materials for use between the glass and the metal. This was in 1886, and he then proceeded to develop such a material that would withstand the pressures and temperatures. With this as a beginning, the firm of Richard Klinger Limited, has grown to its present size, with factories in this and other countries.

The jointing that was developed consisted of asbestos fibres bonded together with rubber, and this is still the main output of the firm. A close second to it are the various types of level gauges which are now being made ranging up to types for very high pressures in the oil industry. To cope with the increased demand, a new extension to the factory at Sidcup has been erected, having a floor area of approximately 30,000 sq. ft. on three levels. This extension was officially opened on May 8 by Mr. Reginald Maudling, Minister of Supply, who was introduced by Miss Pat Hornsby-Smith, Parliamentary Secretary to the Minister of Health, and Member of Parliament for the Chislehurst district, in which the Sidcup factory is situated.

A feature of the new buildings is the use for heating the premises of the waste heat from

the Diesel engines which drive the power station. The cooling-water system is used because this supplies a large quantity of heat more or less irrespective of the loading on the Diesels; the only disadvantage of this system is that the temperature of the water available is about 140 deg. F. and therefore the heating surface has to be large in order to obtain the necessary transfer.

This has been accomplished in the new buildings by using pipes sunk into the floors, except in the case of the machine shop where such an arrangement would interfere with the bedplates of the machines. Radiators have therefore been used in this section.

Although fairly costly to install initially, Sulzer Brothers (who were responsible for the design and installation of the plant) estimated that the cost will be repaid in rather less than four years. As an additional precaution to conserve heat the northern windows of the new building are all double glazed.

The factory is a very self-contained unit for, as already implied, it produces most of its own power, draws its own water from two wells within the grounds, and even supplies the canteen from its own farm, which is behind the main building.

In his opening speech Mr. Maudling emphasised the dependence in this country on the medium size factory (Klinger's employ approximately 650 people) which seems to be the basis of industry. It was notable that in the medium size range, good relationships existed and special needs could easily be catered for; Richard Klinger Limited, had a very good export record, approximately half of their products going abroad directly and an unknown quantity indirectly, and were meeting foreign competition on its own field. The range of products has now extended beyond the original jointing material to such fields as silicone rubbers and mouldings in P.T.F.E. Another line is a plastic-faced material for working surfaces which will withstand a hot iron or a cigarette without damage.

★ ★ ★

Productivity in Freight Handling

Perhaps the most important conclusion of the British Productivity Council's recently published "Review of Productivity in Freight Handling" is that in the road transport industry, which handles about three-quarters of British domestic freight traffic, any improvements in freight handling achieved by modernised loading and warehousing systems are, unhappily, largely offset by the serious inadequacy of Britain's roads. This situation can only be remedied by the large-scale construction of new highways and calls for action by the Government.

The review surveys recent improvements and shortcomings in freight handling by British Railways, by road transport operators, and at the docks. In all of these there have been noticeable increases in productivity since the second World War, in some instances by as much as four or five times; these improvements have been brought about by the adoption of the pallet system, particularly on the railways, and the use of fork lift trucks; by the increasing use of bulk transport vehicles on the roads and improved rolling stock on the railways; by better warehouse facilities; and by the wider use of mechanical handling equipment at the docks.

There are, however, still many areas in which little improvement in productivity has taken place, sometimes due to the indifference of management and sometimes because the operatives will not accept the idea of redeployment following the introduction of new equipment. In the docks, particularly, there is some difficulty in achieving the co-operation necessary between workers and employers. It is probable, too, that better results could be achieved if more attention were paid to work study of the conditions under which freight is handled, a point which has already received attention from the British Railways Productivity Committee. And, although there have been improvements in individual sections of the freight-handling industries, there is a need for closer integration between the various forms of freight transport and for the development of standard interchangeable equipment.

The review can be obtained from the British Productivity Council, 21, Tothill-street, London, S.W.1, price 2*s.* 6*d.*

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Wanted—Accurate Design Data

Speaking at the six-monthly luncheon of the British Gear Manufacturers' Association, Dr. H. E. Merritt remarked that facts and arguments were by no means the same thing, and facts about gear design and engineering data in general varied so much from place to place and from time to time that they had more in common with arguments. Published values for bending stresses of certain materials, for instance, changed each year so that the variation seemed to be about 1·04 per cent. per annum. Conferences and discussions seldom produced any definite results; they were, he said, quoting Samuel Johnson's *Rasselas*, occasions on which people would "unbend their minds and compare their opinions," but at the end "neither party could remember on what their thoughts began."

It was time that a code of design practice was formulated; at present a little positive evidence was called upon to go a long way. There was no difficulty in drawing a smooth curve through two points; nowadays it was frequently the practice to draw a family of curves through one point, and afterwards the point became relatively insignificant. There was certainly a shortage of information, but at least it would be a step in the right direction if the work already available were properly collated, and then something practical for everyday life might come of it. It was in fact one of the functions of the B.G.M.A. to bring the practical needs of industry before the eyes of research teams.

The luncheon was held on May 15 following the presentation of a paper on "Some Aspects of the Loading of Gears and Roller Bearings," by Mr. W. J. Davies, chief transmission engineer, Aero Division, Rolls-Royce, Limited.

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Gas-Turbine School

A true story told at the School of Gas Turbine Technology concerns the engineer who attended one of the school's three-week courses and then went home and built a gas turbine of his own. The unit proved so successful that a slightly modified version is now made commercially. No anecdote, however, is necessary to confirm the remarkable contribution made by the school to the growth of gas-turbine science, and the pre-eminence of Britain in this field both as to fundamental knowledge and ingenuity of design may to some extend be traced to the school's existence.

Founded in 1944 to instruct dominions air force personnel in the application of the gas turbine to aircraft propulsion, the school has since extended its scope and curriculum to cover all branches of gas-turbine technology, including industrial applications. It was first operated by Power Jets Limited and then by the National Gas Turbine Establishment that in 1948 was taken over by Power Jets (Research and Development) Limited, who continue to serve in this capacity. This company, which is nationally owned, is responsible for the exploitation of a large number of British patents covering almost every aspect of gas-turbine engineering and design; it also retains a staff of engineers, who are available for consultation and for the design of gas turbines and allied equipment.

The School of Gas Turbine Technology at Farnborough, Hampshire.

By virtue of this arrangement the school is served by instructors who are also practising engineers and in touch with the most recent developments. It is also extremely well equipped, possessing more than twelve gas turbines together with a comprehensive range of components and various test rigs. Post-graduate courses in either aero-engine or industrial-turbine design last for three weeks, while a practical course of two weeks' duration, and advanced courses of one week, are also held.

It is perhaps unfortunate that residential courses of this kind covering other aspects of engineering science are not available, for it is important, if Britain is to retain her place among industrial nations, that engineers should occasionally have the opportunity to return to their studies in order to keep abreast of new developments. If such courses were to be widely adopted, the school at Farnborough Place would provide the perfect model.

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New Economic Enterprise?

Largely unnoticed during the past fortnight in the midst of all the fracas about the automation "strike" and the under-water spying, the "three wise men" came to Paris—Mr. Dulles, Mr. Selwyn Lloyd and M. Pineau. They came on a mission labelled "the most important task since the foundation of N.A.T.O." They discussed with their colleagues from other countries the future of N.A.T.O. as a means of implementing a new Western policy to counter the Soviet Union's "peaceful co-existence" coupled with what may become highly aggressive economic and political infiltration. The first call for a new policy was made at the end of last month by President Eisenhower, who urged a massive and sustained effort by the West to meet the aspirations of under-developed countries for political independence and progress. This was promptly followed by a proposal from Mr. Dulles to extend the dormant economic and political functions of N.A.T.O. to meet the Soviet pressures both within the Atlantic community and in other parts of the world. Mr. Adlai Stevenson backed both and urged that more economic aid should be made available by the United States but channelled through the United Nations, without which it would not be politically acceptable.

The mission of the three senior foreign ministers was not easily accomplished and it is difficult to predict what the next move will be, but fairly certainly it will be an economic offensive through one of the political organisations set up by the West since the end of the war: N.A.T.O., the Colombo Plan or the Baghdad Alliance. The American belief in the necessity of channelling such aid through these organisations or through the United Nations is most strongly held. This could mean a freer participation by British and other European concerns in the development schemes in under-developed countries than has been the case so far.

A recent analysis of United States construction work abroad (*Financial Times*, May 9) showed how widespread and extensive this has grown in recent years. The new economic aid programmes, whether through N.A.T.O., U.N. or any other organisation, must provide for equal opportunity for British companies. The advanced scale of investment expected to take place over

the next de... great new opportunities could and should ... for British engineering.

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Exhaust Fumes

There has ... been argument in this country, brought to a ... tch by the recent Clean Air Bill, as to how mu... pollution is caused by the gases of motor vehicles. The problem, of course, exists in other countries as well, and various methods are being undertaken to try and estimate it. Much work was done during the smog periods on the identification of the causes of pollution but the results of the enormous amount of data collected are not yet fully available. In this country the Royal Automobile Club have appointed a sub-committee to inquire into the matter and on that Committee are members representing the Road Haulage Association, London Transport, the taxi companies, and many other users of vehicles, as well as a number of technical members. The Committee meets regularly with the intention of trying to obtain cleaner exhausts by persuasion rather than by legislation, and they are supported in their efforts by Government Departments. In the United States of America it is now announced that an agreement has been made between the Bureau of Mines and the Co-ordinating Research Council under which the Council will finance intensified studies on the analysis of exhaust gases from the point of view of air pollution, to the extent of 36,000 dols. this year. This will supplement other work already under way at the Bureau's experimental station at Bartlesville, Oklahoma. The experimental study will attempt to determine whether gas chromatography can be adapted to the analysis of gases. The method requires smaller samples than are needed for some others and can be carried out very rapidly.

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C.I.M.A.C.

To further the spread of knowledge of work in Britain on internal-combustion engines, a committee was formed in September, 1954, to secure and maintain United Kingdom representation on the permanent committee of the International Congress on Combustion Engines (CIMAC) and particularly to encourage the participation of United Kingdom interests. The first report of the British committee has now been published. It would appear that the two main objects have been well accomplished for a delegate has been present at all the meetings of the permanent committee since October, 1954, and the United Kingdom participation in the Hague Conference of 1955 was arranged by the body. The delegation at the Hague was the first official one from the United Kingdom and totalled over 100; it was the second largest visiting contingent present.

Three papers were accepted from United Kingdom sources for the Hague Congress; as a proof of further progress, when the papers committee met in March of this year to consider synopses submitted by the supporting countries in connection with the 1957 Congress, no less than 12 papers were submitted by United Kingdom authors, and of these, five were selected—a very encouraging number in view of the fact that only 27 papers will be discussed during the session and synopses were invited from 11 different countries. The subject for the 1957 Congress will be "Supercharged Diesel Engines and Combustion Turbines in Various Spheres, Marine, Traction and Power Stations."

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Passenger Tonnage

A steady ... of passenger ships has been put in commis... over the past year or so. They have had ... umber of technically interesting features at... them but they represent no more than a res... ble trickle of orders through the yards con... with the flood of tanker business which has ... placed. The reasons for this are clear enough. Passenger vessels are expensive and delays in delivery make them vulnerable to large changes in the expectation of their earning power. He is a brave shipowner to-day who will take a strong view on the 25 years' prospect of a passenger ship on a competitive sea route, especially if that route is open to air competition. Beyond the oil-burning, and gas-turbine ship, too, lies the atomic age which may yet revolutionise sea travel in the next two or three decades.

Under such conditions, a policy of canny replacement rather than bold innovation is likely to commend itself. The latest example of this is the £12 million of new tonnage expected to be placed shortly by Royal Mail Lines, representing three vessels of about 17,000 tons each. These, at about 3,000 higher gross tonnage each than the four vessels they replace, will altogether represent a smaller tonnage—51,000 tons against 56,000 tons. As would be expected, they will be bigger, faster and have better amenities, but they are hardly likely to represent a revolutionary approach to the River Plate trade.

In this context of caution, it is of interest that the Queen Mary, 20 years old this year, is being given a new lease of life with the installation, at a considerable cost, of Denny-Brown anti-roll stabilisers in 1957. This suggests that the ship is possibly destined for a life of 25 or even 30 years and the the replacement decision on her, and on her younger sister, has been postponed for a few years. It is an understandable attitude when over 160,000 tons of shipping are involved.

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Cans, not Tins?

Our transatlantic cousins, who exhort us so earnestly from holiday resorts in Puerto Rico and Hawaii to put an end to our outmoded colonialism, are getting a bit worried by the possibility of our taking their advice in Malaya before they have got a substitute for tin. They might, of course, put the reserves of Fort Knox to good use by gold plating their steel strip, but meanwhile some economically less exciting expedients of considerable technical interest are in hand. One of them, according to a recent announcement by the American Can Company, is known as margin plating and involves plating only the narrow margins of steel strip which form the soldered sideseams of cans. The company is already producing cans for coffee and pet foods by the new process and expects soon to install equipment for using it on beer cans.

During the war lacquered steel was, of course, used for many cans owing to the shortage of tinplate and, although life of the can would probably be shorter, there seems to be no fundamental objection, except possibly in the case of the more acid fruits. Aluminium-coated steel was also used as a tinplate substitute during the war (produced, so far as we are aware, by passing steel strip through a bath of molten aluminium, analogous to hot-dip rather than electrolytic tinning) and appears to be still used to some extent. Another possible alternative to tinplate is an aluminium-coated steel strip technique developed by the Continental Can Company who are believed to be working along lines using a vacuum-coating technique.

Such technical developments, if they were introduced on a large scale, would obviously have a very serious effect on tin consumption, about 40 per cent. of which goes into tinplate. They would also have a serious effect on the balance of payments of the whole sterling area, let alone Malaya itself, which has already had to face the effects of competition from synthetic rubber.

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Ruins of the Future?

According to the annual report of African and European Investment, the Orange Free State gold mines have so far involved a capital investment of £167 million, of which about £95 million (57 per cent.) has geen contributed by the Anglo-American Corporation Group. One of the characteristics of all industries, nowadays, including mining, is that the minimum essential machinery and plant to do the job in hand represents a constantly decreasing proportion of the total capital required for the purpose. Even though towns like Welcom and Odendaalsrus make an amazing contrast to the bare veldt from which they sprang so very few years ago, it is still not easy to get people (especially key technologists and technicians) to go and live there, and a large part of the capital has been spent on civil engineering unconnected with mine or mill, as, for example, on housing, hospitals, clubs, gardens and other amenities. The lives of the mines are limited, possibly to an average of 50 years, and all started about the same time, but there is not yet, at any rate, much prospect for secondary industry in the middle of the O.F.S., though industry has before now been attracted to centres of population which offer no other good reason for them. Is Welcom to be the Merthyr of the Twenty-first Century or will the whole of white Southern Africa have by then been engulfed by a tide of racial hatred, leaving the head-gear of the O.F.S. mines in much the same condition as the ruins of Zimbabwe—and the surrounding civilisation at about the same level as when Ruins of Africa Limited was first filed with the Registrar of Companies?

On the whole the capital sunk in the O.F.S. mines has been well spent. Freddies seemed until recently to be the outstanding exception, though the future of a few other properties such as Loraine and Merriespruit seemed a bit dubious. Now there are cautious rumours of a little clearing even in Freddies' gloomy forest, though whether the company will get out of the wood without yet another capital reconstruction is another matter. At any rate the rise in Free State Geduld shares will benefit Freddies' still-substantial holding, and it seems possible to hope that this time the rise really is based on values encountered in the "rich patch." Most who invest in gold mines seek a capital profit, and so far more of the capital profits have gone into the coffers of the mining finance houses than into the overdrafts of investors. Despite the high rate of output of "suckers" they will not put up another £167 million on that basis.

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Airline Operations

Profitable air transport operations depend on a full payload for available aircraft and keeping them in the air as much as possible. A corollary to this might be to find a formula which will combat seasonal fluctuations. In this respect, the results of the British and Dutch airlines show some interesting contrasts.

K.L.M. Royal Dutch Airlines, who offer world-wide passenger and freight services, earned £1·75 million net profit in the year ended December 31, 1955, but carried only 725,000 passengers. While this represented a 6 per cent. increase over the previous twelve months' figure, it is still only one-third the number of passengers carried by British European Airways, which concentrates on short runs between European terminals. Yet B.E.A. earned only £500,000 net profit in the year ended March 31, 1956. The explanation lies in part in the fact that B.E.A., who make a sizeable profit in the peak tourist season, lose heavily in overheads when the Viscounts and Elizabethans (which are expected to earn £47,500 a month and £35,000 a month each respectively in the coming summer season) have excess capacity in the off-peak winter months. K.L.M., meanwhile, probably maintain a steady revenue all the year round. This is not only because there is far more regular business and less seasonal tourist traffic on transatlantic than intra-European flights, but also because they spread their risks by carrying a relatively large amount of freight. In 1955, for instance, K.L.M. aircraft flew 139,250,000 ton-miles compared with B.E.A.'s total of

7,548,000. But these are all matters of degree; B.E.A. must not be thought to be ignoring freight traffic. Although their absolute amount carried is small compared with K.L.M., their increase of 32 per cent. over the amount carried in 1955 compared favourably with K.L.M.'s increase of 15 per cent.

B.E.A. were also not without troubles outside their own control last year. The chairman, Lord Douglas of Kirtleside, commenting on the net profit figures, has said that the French air-terminal strikes in November and December, 1955, are estimated to have cost the company £100,000. To this factor must be added the effect of the economic situation in this country on winter tourist traffic, and the political situation in Cyprus and Greece. Actual revenue during the past year, at £21·5 million, in fact compares favourably with the K.L.M. figure of £34·8 million, when considering the wider scope of the latter's activities. The fact still remains that K.L.M. were able to allot about £1 million to reserves, and reserves are critically important in this highly competitive industry.

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Oil Reserves and Refining Problems

The world's proved oil reserves are becoming concentrated at a high rate in the Middle East. At the end of 1955, "published proved" oil reserves in that area were 16,800 million tons compared with 4,000 million tons in North America. This fact and a most useful compendium of other oil statistics were published last week by the British Petroleum Company Limited in a *Statistical Review of the World Oil Industry*, 1955. The figures also emphasise the growing problem of balancing refining through-put to meet the demands of the world market.

Total demand for refined oil for the world as a whole went up by 11 per cent. during last year. In the United States oil consumption rose by 8 per cent. following the economic recovery. The largest rate of increase, however, was in Western Europe where the advance was 17 per cent. Certain basic issues emerge from this. First, the United States is now an important net importer of oil, the two largest exporting areas being the Middle East and the Caribbean in that order. The biggest importing area, however, remains Western Europe. In 1955, the latter imported 115 million tons, the U.S. 64 million tons.

While world oil consumption (crude equivalent) went up 11 per cent. from 756 million to 786 million tons, world refining capacity advanced by less than 5 per cent., compared with 9 per cent. in 1954. If the re-opening of the Persian oil refinery is excluded, there was hardly any increase in capacity west of the Iron Curtain. Thus sales of refined oil are overtaking capacity fairly quickly. More than that, the demand, especially from Western Europe, is for the heavier oils (as opposed to petrol) due to the chronic shortage of solid fuel. Refinery capacity is thus not only losing ground as sales increase; it is also getting out of balance. Even the flexibility of the catalytic cracking process cannot be pushed too far and the question of what kind of new plant is wanted and where to put it, near the market or near the oilfield, is now renewed after a decade of quiescence.

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Rise of the Plant Engineer

The contribution which the plant engineer has made to progress in the past, and will make in the future, was the theme of the 9th annual conference of the Incorporated Plant Engineers, held at Harrogate from May 16 to 18. Mr. L. C. J. Bayley, A.M.Inst.Pet., who was installed as the Plant Engineers' president at the opening of the conference, said that in the ten years since the I.Plant E. was founded, the membership had grown to about 3,000, and that there are now 18 branches in the United Kingdom; others exist overseas, and an arrangement has been concluded for a member in West Africa to become corresponding member for that area. Of the future, Mr. Bayley said that the Incorporated Plant Engineers had set high standards, and he ventured to prophesy that within the next ten years they will have become a chartered institution, with a membership of at least double the present figure.

Two papers were presented on "The Plant Engineer and Work Study," the first by Dr. J. E. Faraday, and the second by Mr. G. H. Case, A.M.I.Mech.E. In the discussion which followed the two papers, some interesting points emerged, not the least of which was the fact, mentioned by Dr. Faraday, that the critical examination of a process or operation, which is a vital stage in basic work study procedure, has been known to disclose that the operation was entirely unnecessary, in spite of the fact that it had been carried out for years. The question of redundancy was raised, and it was pointed out that progress in applying work study might have to depend upon the rate at which men could be found other employment. Mr. Case mentioned a large capital development programme with which he was associated, in which work study was of the greatest importance, as it enabled extra work to be done without extra labour, which could not be obtained.

Mr. Richard H. Morris, editorial director of *Plant Engineering* (Chicago), gave his impressions of the conference. He said that the problems facing the plant engineer in both Great Britain and the United States were very much the same. Ten years ago in his own country the plant engineer was not recognised. A survey of educational institutions made at that time showed that the majority had no courses of interest to plant engineers. To-day, as in Great Britain, the plant engineer was firmly established, with his own institution. It was a matter of interest that the American Institute of Plant Engineers was very largely modelled on the British organisation. Mr. Morris said that the problem of attracting suitable young engineers to the profession was the same in both countries, and he asked for everything possible to be done to this end. A conference such as the one he was then addressing could be of value in this connection if it contained items of special interest to young men.

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Industrial Films

The conference on Films as an Aid to Management organised by the industrial committee of the Scientific Film Association, and held at Ashorne Hill, Leamington Spa, from May 16 to 18, revealed that the film has an important part to play in industry. This point was made apparent in the opening address by Mr. J. P. Martin-Bates, managing director of Production-Engineering, Ltd., who referred to the fact that while the film is notable for its clarity the spoken word is notoriously ambiguous. In view of the fact that management in any field is both an art and a science, combining the receiving of knowledge on the one hand and the passing on of this knowledge on the other, it would seem that the film, if well made and wisely used, can render the passing on of knowledge more effective. Mr. Martin-Bates referred to the subject of automation, and asked could not the film have been used by management to prepare the workers for its coming?

Sir Arthur Elton, from his wide experience of the documentary film, gave much valuable information to those contemplating the making and using of films in industry. He said management must ask themselves why the film is being made and who is going to use it, before embarking on actual production, and must co-operate with the film maker in the initial stages. Sir Arthur left his hearers with the important proviso that the film must be used as an instrument with a purpose, and not as an excuse for wasting time. One of the most telling speeches of the conference came from Mr. L. Gould-Marks, of the Visua Aids Section of the European Productivity Agency, who gave a fascinating account of the work of the Agency and the peculiar problems which has to face in making films in the international field. Mr. Gould-Marks went on to give some sound advice to management on the use of the visual aid, stating that management should use and integrate all forms of visual aid in order to convey an idea effectively.

Group discussions formed the focal point of the conference. The 80 delegates were divided into seven groups to discuss such subjects as work study; health, safety and welfare; works information; technical education; supervisory training; operator training; and recruitment and vocational guidance. The groups later reported their conclusions to the conference using film illustrations to make their points. These reports were summarised by Mr. Edgar Anstey, Films Officer of British Transport. The groups were in general agreement that the Scientific Film Association could perform a valuable service by providing comprehensive catalogues of the films already available and also in the co-ordination of production and in the provision of courses in film making. It was felt that a useful purpose would be served by inviting members of the trade union movement to the next conference of this nature in view of the fact that the trade unions at present make very little use of film.

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TURBOJET PROSPECT

The largest of to-day's turbojet engines are probably too large for optimum specific weight, and the trend for increasing thrust has probably reached its peak. These are the views Mr. James Hodge, chief engineer of Power Jets (Research and Development), Limited, expressed in the final lecture of a post-graduate aero-engine design course held at the School of Gas Turbine Technology, Farnborough. For the aircraft working in the 600-800 m.p.h. cruising range, Mr. Hodge foresees a prosperous future for the bypass type of engine which, like the pure turbojet, can profit in terms of thrust-to-weight ratio by the use of higher turbine inlet temperatures; but, unlike the turbojet, its specific fuel consumption will not be adversely affected. The bypass engine, moreover, is much less noisy —a characteristic which, Mr. Hodge considers, must in the future receive more consideration than it has hitherto. Although not concerned with rocket motors, Mr. Hodge drew attention to the possibility of applying the bypass principle to the rocket, by using a ducted fan in the rocket exhaust to draw in air, reducing the jet velocity and increasing propulsive efficiency.

There will be a closer integration of airframe and engine, with the latter contributing directly to lift. This is another reason for favouring a battery of smaller engines rather than fewer large ones. Unless extremely light and compact engines can be developed purely for take-off purposes—used in conjunction with more orthodox engines for forward flight—there seems to be no great future for the pure vertical take-off machine. A more logical solution appears to be the deflected jet to assist take-off, with the jet flap (ENGINEERING, vol. 180, page 722, 1955) as the ultimate answer. Here, again, a number of small bypass engines seem the most suitable means for spreading a relatively cool jet across the span of the aircraft, and for attaining maximum reliability. With the full development of the jet flap, used in conjunction with boundary layer suction to reduce aircraft and air-intake drag, a speed range from 35 m.p.h. to 600 m.p.h. can be envisaged.

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In view of the continued increase in the activities of de Havilland Propellers, Limited, two new appointments have been made within the engineering team led by Mr. G. C. I. Gardiner, the company's technical director and chief engineer. MR. G. H. F. BROWN, A.F.R.Ae.S., chief designer, is appointed assistant chief engineer; MR. C. C. WILLIAMS, who has been engineering manager since 1953, becomes engineering and general manager.

THE FORMABILITY OF ALUMINIUM ALLOYS

By E. A. Barlow, M.SC.*

(Concluded from page 368)

CALCULATION OF DEEP-DRAWING PROPERTIES

A circular cup drawn from a circular blank is considered, being the simplest example of its type. The maximum reduction in deep drawing is that at which the maximum punch load developed during the drawing cycle is equal to the strength of the cup in tension. Chung and Swift[14] have calculated punch loads with very great accuracy, but the calculation even for one material is very lengthy. By using some of their results and a number of approximations however, it is possible to produce a fairly simple formula for punch loads giving sufficient accuracy for most purposes. The strength of the cup walls, on the other hand, can at present be calculated only approximately, and this is the most serious theoretical limitation. Practical difficulties are the determination of the true stress-strain curves for sheet in compression and the measurement of the coefficient of friction under deep-drawing conditions.

The total punch load includes that due to friction, the tension required to pull the sheet over the die-profile radius, and the major load imposed by the circumferential compression required to form the cup. The latter depends on the work hardening of the material and the geometry of the cup. As drawing proceeds the load at first rises because of work-hardening but the amount of material being deformed is decreasing, so that the load reaches a maximum part-way through the stroke.

Stress Due to Plane Radial Drawing.—Considering plane radial drawing only (Fig. 18), and ignoring friction and bending over the die-profile radius and stress in the "thickness" direction, it can be shown by equating forces on a particular element at any stage that

$$dp_r = -(p_c + p_r)\frac{dr}{r} - p_r\frac{dt}{t}$$

where

p_r = radial tension,
p_c = circumferential compression,
t = current thickness of the element,
and r = current radius of the element.

Although the blank thickens up considerably during drawing, the variation across the flange at any instant is less than 5 per cent., so that for obtaining the value of p_r at a given instant the thickness term, $-p_r\frac{dt}{t}$, can be ignored.

Von Mises' hypothesis for yielding in this case becomes

$$p_1^2 - p_1 p_3 + p_3^2 = f^2$$

where p_1 and p_3 are maximum and minimum principal stresses and f is the simple tensile (or compressive) yield stress. This equation is difficult to handle, so a straight-line relation, a modification of Tresca's maximum shear-stress criterion, is used, namely

$$p_1 - p_3 = 1{\cdot}10\,f.$$

This is the best approximation to von Mises' curve, and although the maximum difference between this and von Mises' criterion could be up to 10 per cent., over the range of tension and compression in plane radial drawing, the difference is very small. Hence

$$dp_r = -1{\cdot}10\,f\frac{dr}{r}.$$

The true radial tensile stress in the material at the mean cup-wall diameter at any stage, p_{RP}, is thus

$$p_{RP} = 1{\cdot}10\int_{r_0}^{R_p} f\frac{dr}{r}$$

where

R_p = mean radius of cup walls ≏ punch radius + ½ sheet thickness.
r_0 = current radius of the rim of the blank.

If the material does not work harden, f is constant and

$$p_{RP} = 1{\cdot}10\,f\log_e\frac{r_0}{R_p}.$$

When f is not constant, the above equation may be evaluated by taking a mean value f_m between that for the metal at the rim (which has received the least work) and that for the metal at the mean cup-wall radius at the considered instant (because this has received the greatest work in the early stages of the draw where the maximum load is reached). The equation may then be written

$$p_{RP} = 1{\cdot}10\,f_m\log_e\frac{r_0}{R_p}. \quad . \quad (1)$$

The quantities r_0 and R_p are known; it remains to evaluate f_m.

At any given instant, each element will have extended in the radial direction and compressed in the circumferential direction. Hill[15] has stated that the representative strain (the strain analogue of the root mean square shear stress) received by each element is directly proportional to the true circumferential strain, $\log_e\frac{R}{r}$, to within 3 per cent. for reductions in deep drawing of up to 50 per cent. where R is the original radius of the element. This means that the current yield stress of any element, whatever deformation it has experienced, corresponds to the circumferential strain received. At the considered instant, the circumferential strain of the rim is known; that of the element at the mean-cup-wall radius can be determined if its initial radius is known.

The original radius of the element at the mean cup-wall radius at any given instant is given by the following formula (derived from the constancy of volume of the element)

$$R = \sqrt{(r_0^2 - R_p^2)\frac{t_m}{t_0} - R_0^2}$$

where t_0 = original blank thickness,
t_m = mean blank thickness at the considered stage,
R_0 = initial blank radius.

All the quantities in this expression are known except t_m. Chung and Swift[14] (Fig. 19) have calculated the thickness strains, due to plane radial drawing only, of materials with various strain hardening characteristics. If the values for t_m are taken from the average curve between that for a non-strain hardening metal (which the harder tempers approach) and that for soft aluminium, the maximum error in the value of t_m for any aluminium alloy is ± 1 per cent. At the point at which the maximum load occurs the error is a maximum of ± ½ per cent. Thus t_m can be established with negligible error, and R can be evaluated. The radial

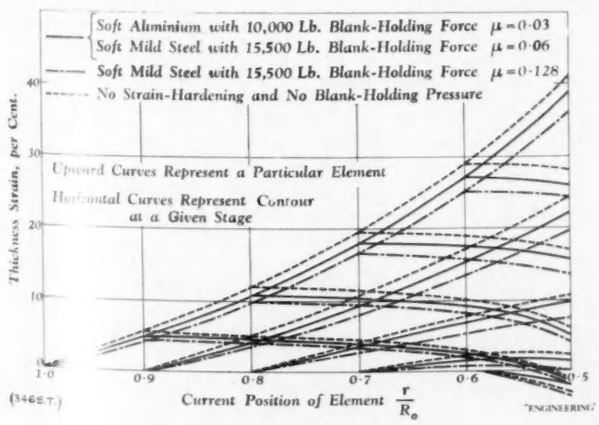

Fig. 19 Development of thickness strain due to plane radial drawing (from Chung and Swift).

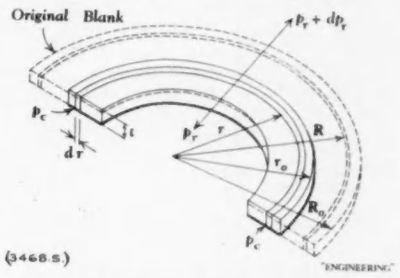

Fig. 18 Plane radial drawing.

strains of the rim and the element at the mean cup-wall radius at the considered stage can be calculated and the corresponding value of f_m obtained from the true stress-strain curve.

Stress due to bending and unbending over die radius.—Chung[16] has shown that the radial stress p_B required to pull the sheet over the die profile radius, i.e. to bend or unbend it, using Tresca's yield criterion is given by

$$p_B \mathrel{\hat{=}} \frac{f\,t}{4\,R_D}$$

where t = current sheet thickness,
f = yield stress,
R_D = radius to neutral axis of sheet ≏ die profile radius + ½ sheet thickness.

When von Mises' criterion is used this becomes

$$p_B = \frac{1{\cdot}155\,f\,t}{4\,R_D}.$$

For simplicity, the value of f for the material at the mean cup-wall radius, f_{RP}, can be taken for bending (this will tend to give slightly high results, as the metal at the beginning of the die-profile radius will have a slightly lower yield stress than that at the mean cup-wall radius). According to Chung and Swift's curves, at maximum load the value of t at the mean cup-wall radius is not much greater than the original blank thickness, and as the load due to bending and unbending is only about 10 per cent. of the total load errors in using t_0 will be small. Comparison with the more accurate (and more complex) formula of Chung and Swift[14] shows an error of about 3 per cent., which is negligible.

If R_D is 10 t_0, the formula becomes

$$p_B = \frac{1{\cdot}155\,f_{RP}}{40} = 0{\cdot}029\,f_{RP}. \quad . \quad (2)$$

Stress Due to Blank Holder Load.—The blank holder load H may be considered as being concentrated at the rim, because this is the thickest part of the flange. The radial tensile stress at the rim due to the blank holder load is $\frac{\mu H}{\pi r_0 t}$, where μ is the coefficient of friction. The radial tensile stress in the material at the mean cup-wall radius, p_{RF}, is given by

$$p_{RF} = \frac{\mu H}{\pi R_p t_{RP}}$$

where t_{RP} is the thickness at the mean cup-wall radius.

Since t_{RP} is not very different from t_0

$$p_{RF} = \frac{\mu H}{\pi R_p t_0}. \quad . \quad . \quad (3)$$

Stress Due to Friction.—In computing the stress at the die radius, allowance must be made for the frictional component. The ordinary slow-speed transmission-belt design formula can be used here

$$T_1 = T_2 e^{\theta\mu}$$

where T_1 = applied tension = p'_{TRP}
T_2 = back tension = $p_{RP} + p_{RF} + p_B$ (i.e., the sum of the stress due to plane radial drawing, the blank-holder stress, and the stress due to bending over the die radius)
θ = total angle of contact = $\pi/2$

whence

$$p'_{TRP} = e^{\mu\pi/2}[p_{RP} + p_{RF} + p_B]$$
$$= e^{\mu\pi/2}\left[1{\cdot}10\,f_m\log_e\frac{r_0}{R_p} + \frac{\mu H}{\pi R_p t_0} + 0{\cdot}029\,f_{RP}\right]. \quad (4)$$

Total Stress.—After being drawn over the die radius

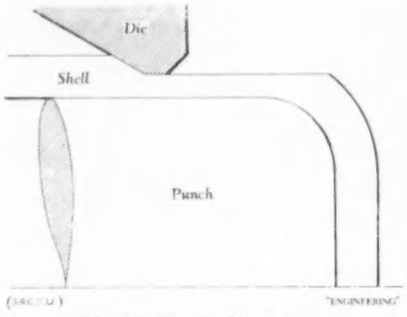

Fig. 20 The ironing process.

the sheet is unbent to form the cup wall. To obtain the total stress the component due to unbending must be added to p'_{TRP}. The stress required to unbend the sheet is $0{\cdot}029\,f_{RP}$, hence the total true stress in the material at the cup wall radius, p_{TRP}, is given by

$$p_{TRP} = e^{\mu\,\pi/2}\left(1{\cdot}10\,f_m \log_e \frac{r_0}{R_p} + \frac{\mu\,H}{\pi\,R_p\,t_0}\right) + (e^{\mu\,\pi/2} + 1)\,0{\cdot}029\,f_{RP}. \quad (5)$$

p_W, the nominal stress (i.e., on original thickness) in the cup wall adjacent to the punch, is therefore

$$p_W = e^{\mu\,\pi/2}\left(1{\cdot}10\,\frac{t_m}{t_0}\,f_m \log_e \frac{r_0}{R_p} + \frac{\mu\,H}{\pi\,R_p\,t_0}\right) + (e^{\mu\,\pi/2} + 1)\,0{\cdot}029\,f_{RP}. \quad (6)$$

FORMING LIMITS

The limit of formability in deep drawing may usually be regarded as the maximum reduction without tensile failure. The calculation of the strength of the cup in tension requires a knowledge of the exact position at which failure takes place, in addition to the amount of work and thinning received by the cup walls and the friction conditions over the punch-profile radius. Moreover, the failing load and position of fracture will be uncertain in the early part of the draw, before the parallel walls are formed. For simplicity the strength of the cup walls is taken as the simple ultimate tensile stress of the unworked material, failure being assumed to take place in the walls near the junction with the punch-profile radius. To calculate the maximum percentage reduction obtainable in deep drawing, the stresses due to the punch loads are calculated for various stages of the drawing cycle for a given reduction, say 50 per cent., and the maximum stress for this reduction obtained. The calculations are repeated for other reductions until the maximum reduction at which the maximum stress does not exceed the ultimate tensile stress of the material can be obtained by interpolation.

This has been done for a number of alloys and values are compared with experimental results for fairly thick sheet (and consequently low blank holder pressure) in Table 2. (Lower results would be obtained with thinner sheet where blank holder pressures must be high.) It will be seen that although individual results do not always correspond closely, the theoretical and experimental values agree in general trend. First, the various tempers of the H20 alloy are all shown to have very similar "drawability" in spite of widely different mechanical properties. Also, the improvement in deep drawability on cold working of NS3 alloy is clearly revealed. Better agreement might be obtained if more accurate values for cup-wall strength and coefficient of friction were available. For the less ductile alloys, H15W and H15WP, values are given for the maximum reduction possible without tensile failure, although the cups cracked in the rim in compression early in the draw.

The accuracy required of the forming limits for practical purposes is about 10 per cent., because a safety factor of this order must be applied to cover variations in material etc. In deep drawing the practical value of a shell is measured by its height in relation to its diameter rather than by the percentage reduction from the original blank. An accuracy of 10 per cent. of the cup height is therefore required. A small variation in reduction from the blank, however, gives a large alteration in cup height, and in terms of drawing reduction, and thus of forming loads and cup-wall strength, an accuracy of about 3 per cent. is necessary. This makes the reliable calculation of deep drawing properties very difficult, quite apart from the complexity of the process itself. The range of values obtained in the present study is from 47 to 54 per cent.; although the range appears to be a narrow one, at 54 per cent. reduction the cup is nearly 50 per cent. higher than at 47 per cent. reduction, for a given cup diameter. A reduction of 50 per cent. in deep drawing is very good, but 40 per cent. would be considered rather poor and 20 per cent. would be useless for cups as it represents a mere turning up of the edge of the blank.

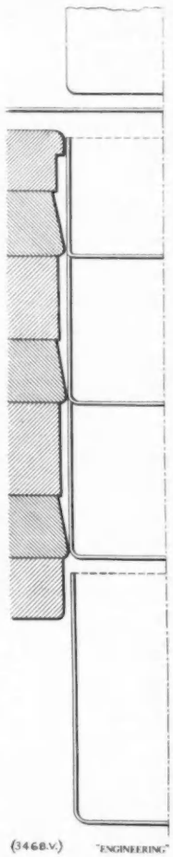

Fig. 21 Keller Press (after British Patent 621, 629).

BLANK HOLDER LOAD AND FRICTION

The blank holder load ranges from zero for thick blanks up to several times the punch load for large diameter blanks in thin sheet, and is roughly proportional to $\left(\frac{R_0 - R_n}{t_0}\right)^2$. With a blank holder load of five times the failing load of the cup and a coefficient of friction of 0·1, the stress in the cup wall due to the blank holder load is $0{\cdot}1 \times 5 \times$ ultimate tensile stress; i.e., the blank holder friction takes up half the drawing load and any variation in the coefficient of friction will make a great difference to the drawability. From a limited number of tests it seems that, for a given set of conditions, although the stronger the material the greater must be the blank holder load, the ratio of blank holder load to the failing load of the cup may be less for the stronger material, which is therefore at an advantage. This is because the wrinkling tendency depends not only on the yield stress, but also on the plastic modulus or slope of the stress-strain curve in the plastic range, so that although the soft materials have a lower proof stress the stress-strain curve in the plastic range is steeper.

It is frequently observed in practice when drawing thin blanks, using a pressure-loaded blank holder, that wrinkling occurs when the quantity of lubricant is excessive. It is suggested that the explanation of this is a purely mechanical one and is not due to any change in friction conditions. With a thick lubricant film, the blank holder is given a clearance in effect, which may allow the blank to wrinkle. A few tests showed that with a normally oily blank, the oil film did not exceed a few ten-thousandths of an inch in thickness, but when too much oil was obviously present the film thickness was as great as 0·0025 in., giving a blank holder clearance of 0·005 in. —enough to allow wrinkling on quite thick (0·036 in.) blanks. The oil film between two parallel surfaces is not rapidly squeezed out even under considerable normal pressure, consequently once an excess of oil has been applied it will tend to persist during plane radial drawing (when the blank is liable to wrinkle), especially in high speed presses where there is little time for the oil to be expelled.

TABLE II.—Calculated and Experimental Values for Maximum Reduction in Deep Drawing

Alloy	Maximum Reduction in Deep Drawing $\frac{\text{(Blank Diameter-Mean Cup Diameter)}}{\text{Blank Diameter}}$ per cent.		Approximate $\frac{\text{Cup Height}}{\text{Cup Diameter}}$ ratio calculated from Blank Diameters	
	Calculated	Experimental	Calculated	Experimental
B.S.1470				
1C—0	49·8	50·0	0·74	0·75
N3—0	48·6	46·7	0·69	0·63
—½H	51·9	48·7	0·83	0·70
N5—0	53·2	54·3	0·89	0·94
H20—0	48·3	51·5	0·69	0·81
—FW	48·1	51·5	0·68	0·81
(Freshly Quenched)				
—W	47·5	51·5	0·66	0·81
—WP	47·6	51·5	0·66	0·81
H15—W	47·3	48·7	0·65	0·70
		(rim cracked at 36)		
—WP	47·0	48·7	0·64	0·70
		(rim cracked at 42)		

OTHER APPLICATIONS

The method of calculation described here could perhaps be applied to allied operations such as the re-drawing of cups. However, there are at least three different methods of re-drawing and it can be done with or without intermediate annealing; there are also certain difficulties not present in single-stage drawing, such as the variation in thickness of the cup before re-drawing.

The method might also be applied to the drawing of rectangular shells, but a few calculations have shown that modification would be necessary. It might be thought that the four corners could be considered as constituting a circular cup, the straight sides being subjected only to bending and straightening under tension. Calculations on this basis, however, yielded low values for the maximum reduction, no doubt due to the fact that in practice some of the material from the corners is not completely compressed, as in a circular cup, but "crowds" into the straight sides. As the amount of compression is then reduced, the loads are lower, giving a greater maximum reduction than would otherwise be expected. This crowding in, which is analogous to the pulling in of material from the straight part adjacent to the radius in bending operations, would be very difficult to allow for in calculation.

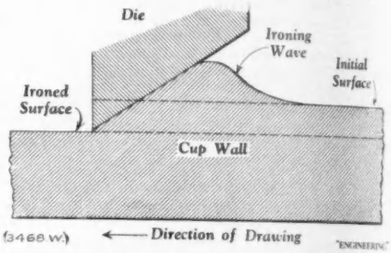

Fig. 22 Formation of ironing wave (after Swift).

SECTION V: IRONING

This consists of reducing the wall thickness of a shell by pulling it through a die (Fig. 20) and is analogous to wire drawing. The process is used for parts requiring a thick base with thin walls, as, for example, cartridge cases. The ironing may be carried out as a single operation, or may be combined with simultaneous deep drawing, either as a small degree of corrective ironing or as a large reduction in ironing combined with a small amount of re-drawing. By using a long-stroke press, a blank can be deep drawn and subjected to several ironing reductions at one operation, as in the Keller press[17] (Fig. 21).

The chief practical difficulty in ironing is the maintenance of a lubricant film between shell and die, for the pressures involved are very high, higher than in deep drawing. The optimum shape for the die is generally agreed to be conical, with little or no edge radius; if the edge radius is an appreciable proportion of the reduction in wall thickness the local pressures generated may lead to breakdown of the lubricant, with build-up on the die, giving scoring and eventual failure of the shells. Swift[18, 19] has shown that for small reductions a small die angle gives the lowest punch loads, and for large reductions a large die angle gives the lowest loads. A suitable angle for most purposes is 10–15 deg.; when the wall thickness is very great it may be necessary to increase the die angle to 20 or 30 deg. to avoid the inconvenience of having to use very deep dies. The finish obtainable depends on the die finish and on the lubricant. At normal press speeds a relatively thick hydro-dynamic lubricant film can be formed provided the lubricant is very viscous so that it is not readily squeezed out from between the shell and the die. A typical matt finish with the least coefficient of friction is then obtained. The usual lubricants, however, are of too low a viscosity for a thick lubricant film to be

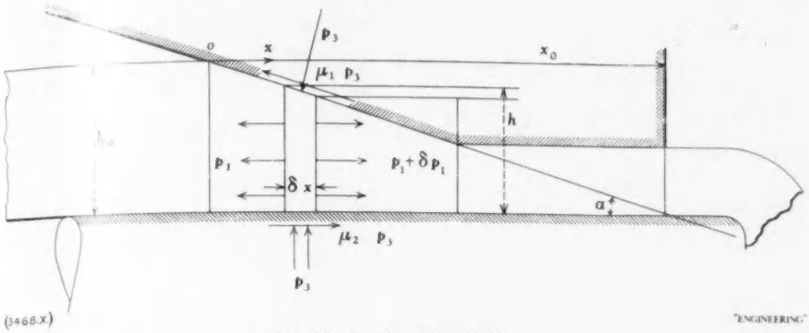

Fig. 23 Ironing (after Swift).

maintained, and only a thin film forms, so that the die finish now has a considerable effect on the surface of the shell, and if a polished die is used a bright burnished shell is obtained. Thin-film conditions are somewhat critical, as the film easily breaks down leading to scoring. Lubrication conditions between shell and punch are much less severe, consequently thick-film lubrication is normally obtained on the inside of the shell, accompanied by a matt finish.

Other practical difficulties occur when the punch is long and slender, as in the Keller press. Near the end of the stroke, bending of the punch may occur because of the uneven height of the shell, leading perhaps to fouling of the punch and die. The thickness near the rim of the shell is then uneven, due to the bending of the punch, and in a subsequent ironing pass slivers of thicker material from the rim may break off; these may lodge on or between the die rings and cause failure of subsequent shells, and perhaps fouling of the tools.

If the die angle is large, the reduction small and the shell wall thick, a "wave" of material forms immediately ahead of the die ring, due no doubt to longitudinal compressive stress at this point; in extreme cases the wave height may be as great as four times the depth of ironing reduction (Fig. 22). Under the opposite conditions, i.e. with a small die angle, thin walls and a heavy reduction, a slight depression appears in front of the die ring. These phenomena complicate any attempt to calculate ironing loads and ductilities; however, the depression is generally insufficient to affect results seriously, and since the ironing wave occurs only at small reductions it is not present at the limiting reductions which are considered here.

For ductile alloys the maximum reduction in wall thickness possible in a single ironing pass is that at which the tensile stress in the already ironed walls, due to the ironing load, reaches the yield or ultimate stress of the material. Since the yield and ultimate stress are very close, as a result of the severe cold working, it is convenient and safer to take the yield stress—indeed it is hardly practicable to work above this stress. Where a number of ironing reductions are being made in one stroke, as in the Keller press, the maximum reduction obtainable at each die ring will depend on whether one pass is complete before the next one is commenced, or whether the shell is in two ironing rings simultaneously during part of the stroke. With the less ductile alloys, if too great a reduction is attempted failure will take place as a longitudinal split in the material undergoing ironing owing to exhaustion of ductility under combined stress. In this respect ironing is similar to deep drawing—failures may occur either from lack of ductility or the inability of the shell walls to withstand the load. As the weakest part of an ironed shell is in the (parallel) ironed walls the failure strength can be easily established, unlike deep drawing where tensile failure may occur at some point over the punch-profile radius. Swift[18, 19] has calculated punch loads in ironing with reasonable accuracy for circular shells with a maximum wall thickness of one-quarter of the punch radius. He has shown that the total punch load consists of two parts, the load in the shell walls and the load carried as traction by the punch as a result of friction between shell and punch. In order to keep the stress in the shell walls at a minimum the friction between shell and punch should therefore be as high as possible and that between shell and die as low as possible. In practice lubrication conditions are far from the ideal.

CALCULATION OF IRONING LOADS

Thin-walled shells. Thin-walled shells, where the thickness is less than, say, $^1/_{10}$ of the punch radius, will be considered first. Fig. 23 shows Swift's assumed stress system on an elementary strip of such a shell perpendicular to the axis of ironing. In fact, the distortion of an element is accompanied by considerable shear, but this will be allowed for later. Since the metal moves forward along the surface of the die, the frictional stress $\mu_1 p_3$ on the outer surface of the elementary strip is in the reverse direction, as shown. On the other hand, since the punch moves forward at the same speed as the fully ironed material, and therefore faster than the metal in the die, the frictional stress $\mu_2 p_3$ on the surface of the strip is in the forward direction. The stress distribution shown is only approximate; the axial stress p_1, for example, cannot be a principal stress, but is associated with a non-uniform shear stress, and varies in intensity from the outer to the inner surface of the wall. Nor in general will the radial stress p_3 have the same value on both surfaces, but as Swift obtained good agreement between calculated and measured punch loads, the approximations are considered justified. Using the notation of the figure, equating forces on the element, and neglecting changes in mean radius during ironing

$$h\frac{dp_1}{dx} - p_1 \tan\alpha = p_3(\tan\alpha + \mu_1 - \mu_2)$$

giving

$$\frac{dx}{x_0 - x} = \frac{dp_1}{p_1 + p_3 + p_3\left(\frac{\mu_1 - \mu_2}{\tan\alpha}\right)}.$$

In a thin-walled shell the circumferential strain can be ignored, hence the material is in plane strain and the circumferential stress $p_2 = \frac{p_1 - p_3}{2}$.

Using von Mises' yield criterion, the yield condition is

$$p_1 + p_3 = 1{\cdot}155 f_1$$

where f_1 is the mean simple tensile (or compressive) yield stress of the material during ironing proper. Hence

$$\frac{dx}{x_0 - x} = \frac{dp_1}{1{\cdot}155 f_1 + (1{\cdot}155 f_1 - p_1)\left(\frac{\mu_1 - \mu_2}{\tan\alpha}\right)}$$

and integrating this, the stress at exit from the die is shown to be

$$p_{1A} = 1{\cdot}155 f_1 \left(1 + \frac{\tan\alpha}{\mu_1 - \mu_2}\right) \left(1 - \sqrt[\frac{\tan\alpha}{\mu_1 - \mu_2}]{\frac{x_0 - x_1}{x_0}}\right).$$

Shear at entry and discharge.—In addition to the "pure" ironing or actual useful work in reduction of wall thickness, there is a shear distortion at entry and exit, as shown in Figure 24. The element will be considered to shear instantaneously at entry, undergo ironing proper and then shear at the moment of exit.

The work done in shear per unit volume $= s_0 \tan\theta$ where s_0 is the mean shear yield stress of the material at entry, and θ is the angle through which the element is sheared.

Work done on a length δx of the cup wall

$$\delta W_0 = \int_0^{h_0} s_0 \tan\theta\, \delta x\, 2\pi r dh$$

$$= \pi r h_0\, \delta x\, s_0 \tan\alpha.$$

This is the work which must be done in the ironed wall by an additional drawing force, F, whence

$$F\,\delta x \frac{h_0}{h_1} = \delta W_0$$

The corresponding mean stress in the ironed walls due to this shearing is therefore $p_{s_0} = \frac{s_0 \tan\alpha}{2}$. Similarly, the corresponding mean stress required to un-distort the metal at exit, $p_{s_2} = \frac{s_2 \tan\alpha}{2}$, where s_2 is the mean shear yield stress of the material at exit. On a material in pure shear (balanced tension and compression) there is no stress or strain in the third direction. Using von Mises' yield criterion, therefore,

$$s_0 = \frac{f_0}{\sqrt{3}} \text{ and } s_2 = \frac{f_2}{\sqrt{3}}.$$

Total Stress.—From the foregoing the total mean tensile stress in the ironed walls, p_T, is given by

$$p_T = \frac{f_0 \tan\alpha}{2\sqrt{3}} + 1{\cdot}155 f_1 \left(1 + \frac{\tan\alpha}{\mu_1 - \mu_2}\right) \left(1 - \sqrt[\frac{\tan\alpha}{\mu_1 - \mu_2}]{\frac{x_0 - x_1}{x_0}}\right) + \frac{f_2 \tan\alpha}{2\sqrt{3}}.$$

For each reduction calculated, the mean yield stresses are determined from the area under the appropriate part of the true-stress/true-strain curve. The quantity f_0 is evaluated between strains of 0 and $\left[\frac{\tan\alpha}{\sqrt{3}}\right]$ (the equivalent strain in simple tension or compression), f_1 between $\left[\frac{\tan\alpha}{\sqrt{3}}\right]$ and $\left[\frac{\tan\alpha}{\sqrt{3}} + 1{\cdot}155 \log_e \frac{h_0}{h_1}\right]$ and f_2 between $\left[\frac{\tan\alpha}{\sqrt{3}} + 1{\cdot}155 \log_e \frac{h_0}{h_1}\right]$ and $\left[\frac{2\tan\alpha}{\sqrt{3}} + 1{\cdot}155 \log_e \frac{h_0}{h_1}\right]$.

Forming Limits.—The yield stress of the ironed walls is influenced by the prevention of circumferential strain by the support given by the punch. Using von Mises' yield criterion, the mean yield stress of the walls is $1{\cdot}155 f_2$, where f_2 is the mean simple tensile or compressive yield stress of the material at exit; this is the stress corresponding to a strain of $\left[\frac{2\tan\alpha}{\sqrt{3}} + 1{\cdot}155 \log_e \frac{h_0}{h_1}\right]$. The maximum reduction at which p_T does not exceed $1{\cdot}155 f_2$ can thus be calculated for a given die angle, if the coefficients of friction are known. In the present case, values were taken from Bland, Whitton and Ford's[20, 21, 22] back-tension rolling results, in which the back tension in rolling was increased until the rolls were about to skid on the strip. The method has the advantage that the coefficient of friction is measured during actual deformation, and the only assumption is that there is no lateral spread of the material, which is true if it is fairly wide. A mean coefficient of friction is obtained over the arc of contact, as is required for rolling theory. The relative speed between strip and rolls under these conditions varies between zero and a relatively small maximum; in ironing, although the type of deformation is not entirely dissimilar, the relative speed between shell and die (although probably not between shell and punch) is higher, and this might be expected to give slightly lower values of coefficient of friction than those obtained in rolling. However, these are the best values available for coefficients of friction under bulk plastic deformation. Values obtained by Ford *et al.* for thin-film lubrication (burnished surface), which usually exists between shell and die, ranged from 0·06 to 0·08; for thick-film lubrication (matt surface),

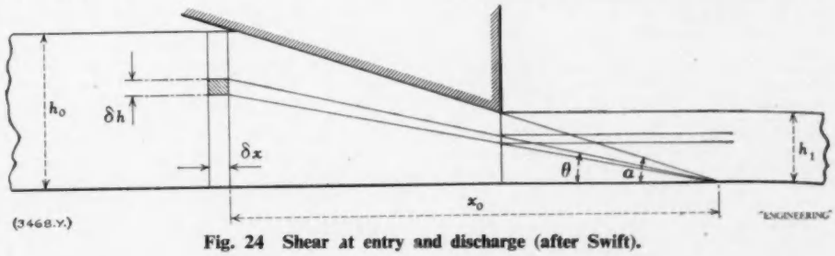

Fig. 24 Shear at entry and discharge (after Swift).

as is usual between shell and punch, values ranged from 0·03 to 0·05. In the present study, for average conditions $\mu_1 = 0{\cdot}07$ and $\mu_2 = 0{\cdot}04$ were taken; for the worst case (without actual breakdown of die-shell lubrication) $\mu_1 = 0{\cdot}08$ and $\mu_2 = 0{\cdot}03$ were adopted. The best condition likely to be met with in practice is that of thick film lubrication between shell and die, with $\mu_1 = \mu_2$. Maximum reductions in ironing have been calculated for these three conditions for various aluminium alloys, for a 15 deg. die. The results are given in Table III. It will be

TABLE III.—*Calculated Values of Maximum Reduction in wall thickness obtainable in Ironing without Tensile Failure*

Semi-die angle 15 deg. μ_1 = coefficient of friction between shell and die. μ_2 = coefficient of friction between shell and punch.

Alloy	Thin-walled cups. Reduction per cent.			Thick-walled cups Reduction per cent.
	Best Case $\mu_1 = \mu_2$	Intermediate Case $\mu_1 = \cdot07$, $\mu_2 = \cdot04$	Worst case $\mu_1 = \cdot08$ $\mu_2 = \cdot03$	Orig. wall thickness / Punch radius $\leqslant 4$ $\mu_1 = \cdot07$, $\mu_2 = 0$
B.S.1470				
1C—0	63	61	60	56
N3—0	59	57	57	52
—½H	58	57	55	51
N4—0	58	57	55	51
N5—0	59	56	55	51
H20—0	58	57	56	52
—FW	59	57	56	52
(Freshly quenched) —W	56	54	52	48
—WP	56	54	53	47

seen that the differences between the three friction conditions are not very great, so that if the coefficients are not very accurate the calculated maximum reduction will not be much affected.

It will be noted that the differences between the alloys are small. This is to be expected because the ability of the ironed walls to withstand the ironing loads does not vary much for different materials; it depends only on the shape of the true-stress/true-strain curve at large strains. Slightly higher values are obtained on the alloys with the higher rates of work hardening at high strains, such that f_3 (determining the ability of the ironed walls to take the load) is high compared with f_1 (determining the major portion of the load). Large differences in the shape of stress-strain curves for different alloys occur only in the initial part of the curve, and since the reductions considered here extend considerably beyond the initial knee of the curve, the differences so apparent between the $\frac{\text{Proof Stress}}{\text{U.T.S.}}$ ratios, for example, are of little importance. Likewise, the effect of prior cold work is small (compare NS-O and NS3-½H) provided only that the material has sufficient ductility remaining to avoid longitudinal splitting. For multiple ironing passes, therefore, the maximum percentage reduction (on the wall thickness from the previous pass) for all passes will be very similar, and failure will finally take place when the fracture ductility under the particular stress conditions is exhausted.

Unlike deep drawing, there is no advantage in reducing the percentage reduction at each subsequent pass, as is often done in ironing. (The percentage reduction on the original wall thickness at each pass will, of course, decrease.) The differences between the various alloys—again in contrast to deep drawing—are probably too small to be made use of in practice, as the difference between, say 56 per cent. and 63 per cent. reduction in the wall thickness of a thin shell is only a few ten-thousandths of an inch. It would be hardly practicable or necessary to work to these limits, especially as variations in thickness of original stock, elastic expansion of die rings, etc., would be much greater than this. The shell height is almost exactly proportional to the percentage reduction, so that an accuracy of, say, 10 per cent. in the value for the maximum reduction is sufficient.

A few practical tests were carried out to check the calculated values of maximum reduction. The maximum reduction obtained on thin-walled shells in S1C-O alloy was 61 per cent., comparing well with values derived from theory; H9-W, the only other material on which results were available, gave a maximum reduction of 52 per cent. This is slightly lower than would be expected, but lubrication was not satisfactory, as there was slight scoring on the shell wall.

THICK-WALLED SHELLS

Swift has adapted the previous formulae for ironing loads for use with thick-walled shells, and obtained good agreement between calculated and measured punch loads for shells up to a wall thickness of one-quarter of the punch radius $\left(\frac{h_0}{r_1} = \frac{1}{4}\right)$. Using the notation in Figs. 23 and 25, the equation for equilibrium of an element is

$$r\,h\,\frac{dp_1}{dx} = (p_1 + p_3)\,r_x \tan\alpha + p_3\,(\mu_1 r_x - \mu_2 r_1)$$

where $r = \frac{r_x + r_1}{2}$.

As the material is not in plane strain the yield condition (using von Mises' criterion) will vary with the amount of reduction and will lie between

$$p_1 + p_3 = 1{\cdot}0\,f \text{ and } 1{\cdot}155\,f, \text{ near to } 1{\cdot}155\,f.$$

Accordingly, $1{\cdot}155f$ is taken, giving a slight underestimate for maximum reduction.

Hence

$$r\,h\,\frac{dp_1}{dx} = 1{\cdot}155\,f_1\,r_x \tan\alpha + (1{\cdot}155\,f_1 - p_1)\,(\mu_1 r_x - \mu_2 r_1)$$

This equation is not readily solved unless $\mu_1 r_x = \mu_2 r_1$, or $\mu_2 = 0$. The first condition is unlikely as it means that friction between shell and punch is greater than that between shell and die; the second case is more nearly correct, as it means no friction between shell and punch, the cup taking the whole of the punch load. This is obviously not so, but the friction is probably less than with a thin-walled cup, and in any event with this assumption the values for maximum reduction obtained will be slightly on the conservative side. Hence

$$p_{1A} = 1{\cdot}155\,f_1\left(\frac{\tan\alpha}{\mu_1} + 1\right)\left[1 + \left(\frac{r_A^2 - r_1^2}{r_0^2 - r_1^2}\right)^{\frac{\mu_1}{\tan\alpha}}\right].$$

Shear at entry and exit is calculated on the same basis as for thin-walled cups, and

$$p_{s_0} = \frac{f_0 \tan\alpha\left(\frac{r_1}{2} + \frac{h_0}{3}\right)}{\sqrt{3}\left(r_1 + \frac{h_1}{2}\right)} \text{ and } p_{s_2} = \frac{f_2 \tan\alpha\left(\frac{r_1}{2} + \frac{h_1}{3}\right)}{\sqrt{3}\left(r_1 + \frac{h_1}{2}\right)}.$$

The total stress is the sum of p_{1A}, p_{s_0} and p_{s_2}, as before.

Values of maximum reduction have been calculated for the various alloys for a 15 deg. die angle and a coefficient of frction $\mu_1 = 0{\cdot}07$, and are given in Table III. It will be seen that reductions are a little lower than for thin-walled cups.

DUCTILITY IN IRONING

A knowledge of the fracture ductility in ironing would allow the maximum reduction to be calculated for alloys the ductility of which is exceeded in the first pass before tensile failure takes place, and would also enable the maximum total reduction in multiple ironing passes to be calculated for the more ductile alloys, which eventually fail owing to exhaustion of fracture ductility.

The fracture ductility of a material in ironing can be calculated along the lines used by Dorn for calculating ductilities in bending, if the yield and fracture criteria are known for the particular stress conditions. For a material to just fail in ironing, fracture will occur at the end of the operation, i.e., at the completion of the final shear. In pure shear, as in thin-walled cups (i.e., balanced tension and compression, with no circumferential stress) the yield and fracture criteria are known, and it is found for some alloys, which are known to fail in ironing by lack of strength and not lack of ductility, that in theory they have insufficient ductility to undergo the two shearing operations, apart from ironing proper. This anomaly is due to the simplifications adopted in assuming that the shearing was instantaneous and separate from the ironing proper, whereas, in fact, the shearing doubtless occurs over a finite distance inside the ironing ring, when the presence of additional compression increases the ductility. For calculating ironing loads and therefore maximum ironing reductions of ductile alloys, the original assumptions are satisfactory, because the shearing loads are only a small proportion of the total ironing load where reductions are large and friction appreciable, as in the limiting case considered here, so that inaccuracies in the shearing load are not important. Even if a more exact stress analysis of ironing were made for the purpose of calculating ductility under these conditions, there is at present no satisfactory fracture criterion for metals under triaxial stress.

Conclusions.—It has been shown that the formability of a material under the chief types of forming operation can be predicted with sufficient accuracy from the stress-strain curves. The need for more accurate information on yield and fracture criteria of different alloys has also been demonstrated. A more accurate calculation of cup-wall strength in deep drawing is desirable and an extension of the method to re-drawing and, if possible, to the drawing of rectangular shells. Other lesser operations which might be amenable to calculation are the shrinking of cylindrical parts, and the bending of tubes with and without internal supports of various kinds. Eventually it is hoped to present the results obtained here in tabular form for use by designers and others.

Acknowledgments.—The author wishes to thank Dr. J. M. Alexander, Mr. L. H. Butler and Mr. G.L. Jones for their many helpful suggestions.

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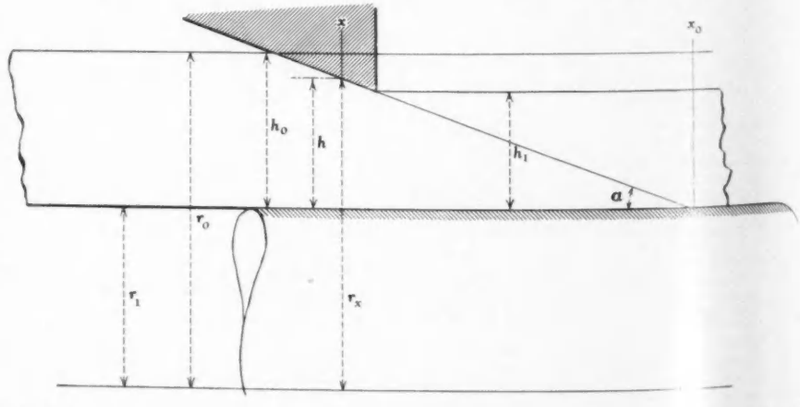
RESEARCH SCHOLARSHIP IN FOUNDRY WORK

The Council of Ironfoundry Association's Training and Education Committee has recently considered the establishment of a research scholarship in foundry work at the University of Birmingham, because all too frequently graduates in foundry work who wish to continue for their Ph.D. degree are obliged to seek scholarships endowed by other industries, and are thus lost to the foundry industry. The Council therefore intends to establish the scholarship in the autumn of 1956, and has agreed to make a grant of £300 per annum for four years for this.



(3468.2)

Fig. 25 Notation of ironing of thick-walled cups (after Swift

INTERNATIONAL ATOMIC CO-OPERATION

If the most profitable use of atomic energy is to be made throughout the world, it will be necessary to devise effective means of distributing and exchanging knowledge and nuclear materials. This pressing need for co-operation has spawned a large number of different plans, some of which seem to overlap, and at least two international organisations carry out or co-ordinate research. Perhaps the most important consideration in connection with these schemes concerns the supply of nuclear fuels, since these are the *sine qua non* of any atomic power programme and must precede any decision by a private company to undertake nuclear power station construction.

POSSIBLE AUTHORITIES

Agencies for the supply and exchange of nuclear materials have been planned by three principal bodies: the Organisation for European Economic Co-operation; the Messina or "Little Europe" group, comprising the members of the European Iron and Steel Community (France, Belgium, the Netherlands, Luxembourg, Italy and Germany) whose agency is to be known as Euratom; and the United Nations, which at the end of April published a draft statute for an international atomic agency. The statute, which has been approved by a twelve-nation committee including Britain, the United States and the Soviet Union, will come before a general conference of the United Nations and its specialised agencies in September. The object of the agency will be to further the peaceful uses of atomic energy throughout the world by encouraging research and development; by acting as an intermediary for the supply of materials, equipment and services by one member to another; by itself making provision for such materials and services and acquiring plant and facilities where necessary; by fostering the exchange of scientists and information; by formulating standards of health and safety; and by establishing safeguards designed to ensure that materials, equipment, services and information made available under agency arrangements shall not be used for military purposes. These controls are to be administered through an international inspectorate with the right to enter the territories of any member state. Inspectors will have access at all times to places, persons and data concerned with fissile material so that regulations regarding its use and the statutory safety precautions may be enforced. Punitive clauses include the suspending of assistance to or membership of states not complying with the provisions of the statute.

Shortly after the publication of this statute an announcement was made concerning the Brussels plan for a collective European atomic energy commission. The plan, which provides for the establishment of the agency Euratom, may be the basis of a treaty and is expected to form part of a more comprehensive "federal" scheme of economic co-operation, which already covers coal and steel. *The Times* suggests that Euratom may be similar in some respects to the United States Atomic Energy Commission, and certain tasks will probably be delegated to various external organisations, including large firms and Government institutions. Though close association with the United Kingdom will be sought, Britain is not likely to be party to the plan, but any country wishing to join a European community may be incorporated. Executive control is to be in the hands of a permanent commission empowered to act, whose members would be appointed by the Governments concerned but would not represent those Governments. The commission is to set up a research centre and college, and is likely to build a uranium separation plant as one of its initial projects. The agency will have first claim on nuclear fuel produced by member countries (the Belgian Congo has considerable ore deposits) and these will remain under its control whether hired or purchased. Free trade without monopolies is proposed for the common market, with yearly cuts in duty of 10 per cent. for the first four years, two cuts of 10 per cent. in the second four and the remaining 40 per cent. removed in a third period. In France, where ratification is still uncertain, the Government have accepted the plan, but it has yet to come before the Assembly. A meeting of ministers representing the six countries has been convened for May 29.

O.E.E.C. has also recently made an announcement concerning its programme. Its Committee for Nuclear Energy, which was established by the Council of Ministers last February, held its first session at the end of March when Professor Leandre Nicolaides, of Greece, was elected chairman and M. Pierre Guillaumat, of France, and Mr. Friston C. Mow, C.B., of the United Kingdom, were elected vice-chairmen. The committee's terms of reference (given in a bulletin of March 12) required proposals in three months time, and on March 30 the chairman reported that the committee had established its bureau and had organised its initial work as follows: a working party were to consider technical and financial problems for the joint establishment by members of an isotope separation plant, a chemical separation plant for irradiated fuels, a heavy-water plant, and prototype and testing reactors; a second working party was to study rules, inspection and verification systems, penalties and the problem of safeguarding manufacturers' "know-how"; the secretariat were to compile a list of materials for the liberalisation of European trade in nuclear products and to submit the findings for comment by governments; and steps were to be taken regarding the exchange of training facilities, standardisation of equipment, and relations with other organisations. The committee hopes to finish its work in June and to present its report to the Ministers when they meet in July.

RESEARCH BODIES

In addition to the three schemes already outlined, there are two research organisations that should be mentioned in the context of international co-operation on nuclear energy. One of these is CERN (European Council for Nuclear Research) which was established in 1953 under the auspices of Unesco and has as its object the planning and operation of an international laboratory. Its headquarters are in Geneva, and its studies are divided under four groups; a synchro-cyclotron group, a proton synchroton group, a laboratory group, and a theoretical group. Its laboratory in Geneva includes a 600 MeV synchro-cyclotron and a further machine of 25 GeV, both of which are still under construction. Though not a signatory to the original agreement, the United Kingdom participates financially and technically in the activities of CERN.

The second international body concerned with nuclear matters already functioning is the European Atomic Energy Society, which was founded in 1954 to promote co-operation in nuclear research and engineering. There are eight participating countries, including the United Kingdom, and Sir John Cockcroft was the first President. The Council meets once a year to consider the report of a working party.

The diversity of plans for international co-operation in the field of atomic energy seems at first sight confusing, but there is as yet no reason to prevent all schemes from proceeding simultaneously. Either Euratom or the O.E.E.C. proposals, or both, could fit into the United Nations project, much as individual countries would take part, though Euratom could probably most easily be accommodated in this way. The United Kingdom, partly because of its lead in atomic energy developmemts, wishes to remain autonomous, and therefore favours the looser O.E.E.C. plan. Thus it may be that eventually international co-operation on atomic energy will be administered for Europe within the framework of O.E.E.C. acting under the United Nations agreement, with Euratom represented in O.E.E.C. as a federal unit. The difficulty of reaching agreement and the unwieldiness of any international organisation may give rise to scepticism, but it can be regarded as almost certain that, in the case of nuclear energy, the pressure of the "have-not" nations—who vastly outnumber the "haves"—will ensure that some effective system of distributing atomic knowledge, equipment and materials will finally emerge.

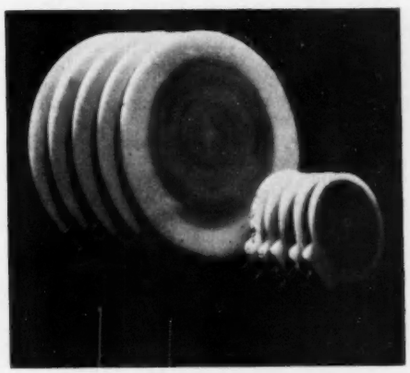
* * *

MEASURING THE FLOW OF HEAT

Thermo-Junction Discs

Discs which can be attached to a surface, and by their generation of a potential give a direct indication of the flow of heat through them, have already been described in these columns (page 47, vol. 178, 1954). Now the same firm, Joyce, Loebl and Company, Limited, Electron House, Simpson Street, Newcastle-upon-Tyne, 1, have produced further types of heat-flow disc of different construction and with far greater output. Two groups of these are shown below.

Two sizes are made, known as the WS.31 and WS.32, the former being 4·3 in. in diameter and the later 2 in. The electric outputs are respectively 714 and 250 microvolts per B.Th.U. per sq. ft. per hour, compared with the 2·5 microvolts given by the earlier Heathfield discs. The WS.31 and WS.32 discs are built up from a very large number of thermo junctions, of the order of 300 per sq. in., embedded in a matrix of polythene; this limits the maximum temperature at which they can operate to 160 deg. F., and the thermal resistance is of the order of 0·08 deg. F. per sq. ft. per hour per B.Th.U. These limitations, however, are more than offset by the enormous output, which makes them suitable for field work where relatively robust and insensitive indicators or recorders are used. The outputs are sufficiently large to permit direct recording.



The heat flow from a surface can be measured by attaching one of these discs; one of the larger size gives an output of 714 microvolts for a flow rate of 1 B.Th.U. per sq. ft. per hour.

Applications mentioned where these discs have been employed are: calorimetry, where they may be embodied in the solid mass; the heat loss from surfaces of furnaces, refrigerated areas or pipe insulation; and extensively in checking the insulation of a structure by measuring the heat flow across its boundaries. One particular application is to fit them on pipes to show the deposition of scale on the inside of the pipe by the change in heat flow that occurs.

INSTRUMENTS FOR OCEAN RESEARCH

THE NATIONAL INSTITUTE OF OCEANOGRAPHY'S TECHNIQUES

Oceanography can perhaps be described as the art of exploring the sources of power and life in the ocean and ultimately directing them for the use and convenience of man. It embraces the chemistry and physics of the ocean—its internal dynamics and thermodynamics and its energy exchange with the atmosphere; the geology and geography of the sea bottom; and the biology of marine life which is intimately linked with the physical aspects. (These physical aspects have recently been the subject of the James Forrest Lecture given before the Institution of Civil Engineers by Dr. G. E. R. Deacon, Director of the National Institute of Oceanography.) It is with some of the instruments that have been developed for the study of ocean physics that this article is concerned.

The National Institute of Oceanography is comparatively young. It was formed in 1949 under the direction of a National Oceanographic Council with the object of advancing the science of oceanography in all its aspects; the Council received a Royal Charter in 1950. The Institute took over the Oceanographic Group of the Royal Naval Scientific Service, and the Discovery investigations, as well as part of the work of the Oceanographic Branch of the Admiralty Hydrographic Department. Although a comparatively small organisation, it has made some notable contributions to the techniques of investigating the ocean's mysteries.

MEASURING NEAR-SHORE WAVES

Some of the work done by the National Institute of Oceanography is of direct engineering significance. The design of aircraft carriers, for example, is likely to be influenced by their studies of ship motion, in which they are measuring pitch and roll using Admiralty-type gyroscopic recorders modified to give an electrical output which is applied either to a photographic recorder or a pen galvanometer.

Methods of measuring the wave height in shallow water (i.e., in depths less than about 50 ft.) are of interest to dock and harbour engineers. The instrument that has proved to be most suitable for this purpose, the piezo-electric pressure recorder, has been in use now for some years and was, in fact, developed by the Oceanographic Group of the Admiralty Research Laboratory before the Group was absorbed into the National Institute of Oceanography. This instrument, illustrated in Fig. 1, has no moving parts to become unserviceable and has, consequently, a long useful life. Placed upon the sea bed, it measures the pressure of the water above it, which varies according to the amplitude of the wave, provided that the mean depth of the water is not greater than one-fifth of the wavelength. Used at depths of 40 to 50 ft., such an instrument will measure the amplitude of the most important waves which, generally speaking, have wavelengths greater than 500 ft.

The piezo-electric pressure recorder operates as follows: the water pressure acts on a piston-like faceplate which bears on a pack of alternate quartz and steel plates. The faceplate is sealed by an O-ring, but the quartz-steel pile is so rigid that the movements are exceedingly small. Changes in the load on the quartz produce an electric charge in the quartz which charges a capacitor. The voltage across the capacitor, amplified electronically, gives a measure of the head of water. The capacitor charge leaks away slowly so that while the instrument responds to comparatively rapid pressure changes from the longer waves, slow changes in head due to the tide are not recorded.

Other methods of shallow-wave recording that have been used by the Institute include simple flexible-bag type pressure recorders, rather limited in scope, and an inverted echo sounder located on the bottom and transmitting signals which are reflected from the water surface. This method is unreliable where the waves are breaking, and is not suitable for waves of short wavelength. For use in experimental tanks and reservoirs, a capacitance wire recorder has proved useful, comprising a vertical insulated wire, the conductor forming one plate and the water the other plate of a capacitor with the wire insulation as dielectric. Changes in water depth thus vary the capacitance which is measured by an electronic circuit.

WAVES IN THE OPEN SEA

Although they have practical applications, these instruments have been developed primarily for fundamental studies on the nature and propagation of ocean waves, and such studies require the measurement not only of near-shore waves but also the formation of waves in the open sea where instruments of the foregoing type cannot be used. Until about three years ago such measurements presented considerable obstacles, depending on free-floating sub-surface pressure recorders, the launching and recovery of which were extremely difficult in rough weather.

To overcome this the Institute has made a fresh approach to the problem with the development of a shipborne wave recorder which is used from a stationary ship, which may be in deep water. This instrument, which is now in use in three research ships in the United States and in the "Norsel" chartered by the French Antarctic expedition, as well as in N.I.O.'s own "Discovery II" and the Air Ministry's "Weather Explorer," is the only shipborne instrument for recording wave height so far developed. It is proving useful in the study of ship motion as well as in wave research.

SHIPBORNE WAVE RECORDER

In principle, the shipborne wave recorder (Fig. 2) consists of two measuring elements—a pressure-sensing element installed in the hull some 10 ft. or so below the water level, sufficiently deep to ensure that it remains submerged when the ship rolls; and, because the ship heaves under the action of the longer waves, an accelerometer measuring the vertical acceleration of the hull. The acceleration signal is fed to a double integrating circuit in an electronic computer to give the vertical displacement of the point at which the pressure is measured relative to an arbitrarily-fixed height datum; and this displacement is combined with the signal from the pressure-sensing element to give the height of the wave above datum.

The pressure-measuring unit is attached to the side of the hull, in which a ½ in. diameter hole is drilled to admit sea water into the instrument casing. A flexible Neoprene diaphragm separates the sea-water from an oil-filled chamber containing a bellows, the interior of which is connected to the atmosphere. The sea-water pressure, acting through the flexible diaphragm on the oil, deflects the bellows against the action of a spring, the resulting movement being transmitted through a connecting rod to a transducer which generates an electrical signal proportional to the deflection.

The accelerometer has a mass hung on a spring enclosed in an oil-filled pendulum casing which

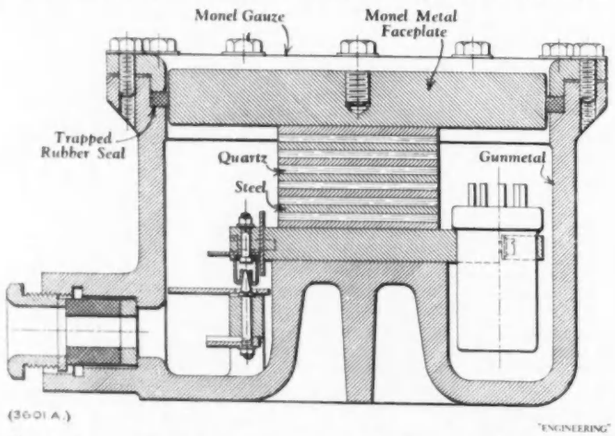


Fig. 1 The piezo-electric pressure recorder for measuring wave heights in shallow water; having no moving parts, it has a long useful life.

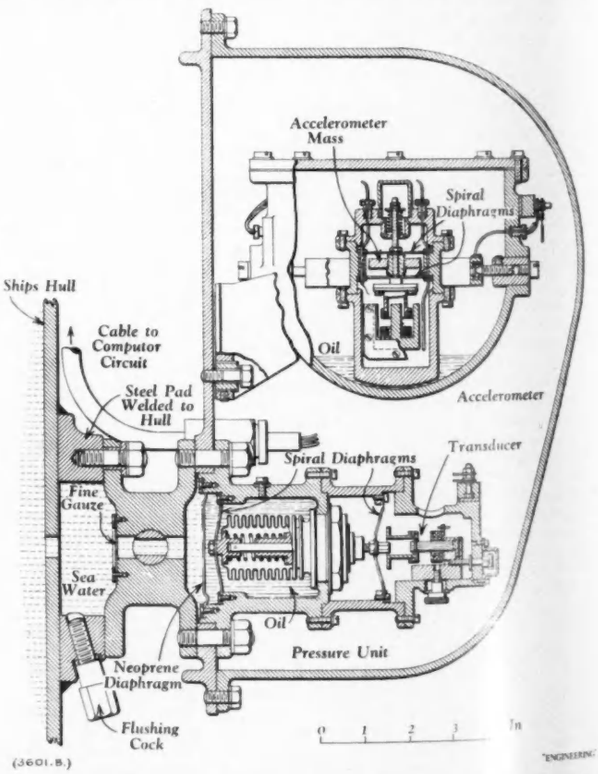


Fig. 2 The shipborne wave recorder for measuring wave hei[illegible] in mid-ocean. It comprises a pressure-sensing element and an integrati[illegible] accelerometer.

Fig. 3 Launching the prototype pitch and roll buoy from R.R.S. "Discovery II" last summer. It records, on a single length of film, pitch, roll, wave height and atmospheric pressure on the surface of the ocean.

is mounted in gimbals in a hemispherical bowl, itself containing oil to damp the pendulum swing. The spring and weight system, which has a natural frequency of about 4 cycles per second, is connected to a transducer similar to that of the pressure unit. The instrument is highly sensitive and accurate, and responds to accelerations ranging from 0·001 *g* to 0·3 *g*.

The arrangement of the electronic integrating circuits and the means by which inaccuracies arising from the effect of rolling on the apparent vertical have been counteracted are beyond the scope of this article. They are fully described in a report of the N.I.O.*

PITCH AND ROLL BUOY

Another recent development directed to studying the mechanism of the generation of sea waves, and to see how they are correlated with wind pressure, is the prototype pitch-and-roll buoy which, launched from Discovery II in the North Atlantic, made its first trials in May and June last year. (Fig. 3).

This device, which comprises a buoy, freely floating apart from a small sea anchor to align it into wind, provides continuous records of pitch, roll, wave height, and air pressure on a single length of film. The buoy itself is a hollow light-alloy drum, 5½ ft. in diameter and weighing, with all its instruments, about 11 cwt.

Within the buoy are mounted gyroscopic pitch and roll recorders; a double-integrating accelerometer of the same type as that employed in the shipborne wave recorder but incorporating a stronger spring; a microbarograph recording the atmospheric pressure; and a recording camera and batteries.

The microbarograph, which operates on the condenser microphone principle, incorporates a thin aluminium-foil diaphragm of adjustable sensitivity, which responds to pressure fluctuations down to about 1 cm. of air. The diaphragm is located in the upper central part of the buoy, and communicates with the atmosphere through 12 small holes in the flat surface of the central cover plate. To ensure that the holes do not get blocked by drops of water they are surrounded by electric heating coils so that any moisture is evaporated; in addition, there are moisture shields and desiccators between the air holes and the diaphragm. Tests have demonstrated that heating the air-entry holes has no apparent effect on the pressure indication. About 4 hours continuous recording is possible before the air holes become salted-up.

The results of the prototype trials are still being analysed; it appears that on calm days the wave-height and atmospheric-pressure curves follow the same general pattern, but this is not the case on rough days, when the wind blowing over the waves produces additional pressure changes. Study of these should throw light on the mechanism of wave generation, which is not yet understood.

* M. J. [illegible]ker, "A Ship-borne Wave Recorder": National Institute of Oceanography Internal Report No. A2. Shortly to be published in the *Transactions of the Institution of Naval Architects.*

AIRBORNE WAVE RECORDER

Another method for studying wave generation that has still to undergo much development is the airborne radar altimeter, with which it is hoped to measure the wave height by reflection of radar signals from the water surface. This technique is designed to study the direction as well as the magnitude of the sea waves, by flying the aircraft quickly over a succession of different courses, thus securing a number of more or less instantaneous cross-sections at various angles. A prototype instrument developed by the Radar Research Establishment has given promising results, but subsequent instruments produced commercially have proved to be disappointing, and the reasons for this are under investigation.

The wave records from all the wave-height recording instruments that have been described are generally pen and ink traces on 35 mm. paper tape in continuous lengths up to 2,000 ft. Converted by means of a photo-electric curve follower into black-and-white profile records, they are analysed in an electronic harmonic analyser developed some years ago by the oceanographic section of the Admiralty Research Laboratory. Such analyses of wave records taken at shore stations have shown that it is possible to distinguish short waves generated by local wind from long swells generated by storms as far away as 6,000 miles. Another interesting discovery, which suggests a new means of providing early storm warnings, is that in a cyclone area standing waves may be caused by interference between similar waves travelling in opposite directions; and that the pressure variations on the sea-bed arising from these standing waves cause minute earth movements which can be detected almost simultaneously by seismographs at land observatories many hundreds of miles away.

OCEAN CURRENTS

The study of deep currents and heat circulation in the ocean, which governs the productivity of the sea, is probably the most important of the N.I.O's tasks. A considerable knowledge of surface currents has already been built up by means of observations taken from lightships, using the Carruthers vertical log, a simple sturdy instrument of the rotating-vane type for operation by ships' crews even in rough weather. Another method employed is to use the water current as an electrical conductor and measure the voltage produced as the water moves through the earth's magnetic field. In this way continuous records are kept of the flow through the Straits of Dover, and the method has also been used on the R.R.S. Discovery II, using two electrodes paid out over the stern, separated by about 100 yards, and proceeding at speeds up to 3 or 4 knots; the electrodes are connected through a smoothing circuit and a direct-current amplifier to a recording milliammeter.

The measurement of deep water movements, however, is only in its infancy, mainly because of the considerable difficulty in developing suitable instrumentation. Within the last 18 months, however, the National Institute of Oceanography have devised a technique for directly tracing the path of a float in a deep-water current up to 1,000 fathoms below sea level, the first occasion on which this has been done; hitherto only spot measurements of the speed and direction of the current at a given depth have been possible, and these have been subject to considerable inaccuracies in deep water.

NEUTRAL BUOYANCY FLOAT

The float, which is expendable, consists of an assembly of two tubular aluminium scaffold poles, approximately 1¾ in. in outside diameter and 10 ft. long, closed at the ends by simple flanged end plugs with O-ring seals. The thickness of the tube is carefully controlled by reducing the outside diameter in caustic soda solution, to increase the buoyancy without risk of collapse at the desired working depth and without seriously increasing the compressibility of the tubes, which must be less than that of the sea water so that, as the float sinks into denser water, it eventually reaches a depth at which it becomes neutrally buoyant. The actual depth at which this occurs is predetermined by adding weights inside one of the tubes which serves as a buoyancy chamber to give the desired density to the float assembly.

The other tube is fitted up as an acoustic

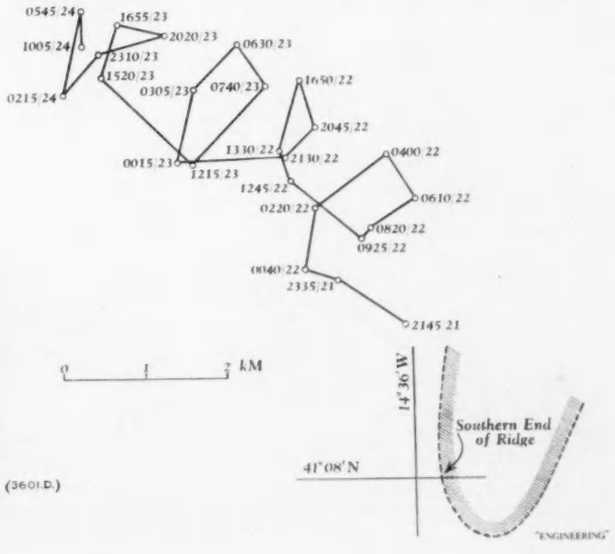


Fig. 4 Plot of track followed by the neutral buoyancy float, submerged at a depth of about 400 metres, during trials on June 21-24, 1955, showing tidal cycles superimposed on the general north-westerly drift. The figures give the hour and date of each observation.

transmitter, with a magnetostriction ring suspended below the float and an electronic circuit and a pack of twelve 30 volt batteries housed in the bore. One insulated lead from the transmitter ring is connected through a ceramic lead-through insulator set into the end plug with Araldite D resin; the other lead is bonded directly to the end plug which forms part of the conducting circuit. The transmitter, which emits a triangular pulse about once every five seconds, is energised by discharging a capacitor through a flash tube.

The audible signals from the buoy, which can be detected about two miles away, are picked up by two hydrophones, one lowered from either end of the ship. With the ship stationary, the bearing of the float can be determined by measuring the time differences between the received signals at the two hydrophones with the ship swung through a series of headings, and plotting the difference as a polar diagram. The time difference is zero when the ship's axis is at right angles to the line joining the float to the ship. The ship is then steamed to other positions and the process repeated; the intersections of the bearings thus obtained fix the position of the float. It is of course necessary to allow for the drift of the ship, and this is done by taking radar fixes on an anchored dan buoy. Drift of the dan buoy itself is checked by soundings over recognisable features on the sea bed.

From the polar diagram of time difference it is also possible to obtain (by comparison with the direct travel time between the two hydrophones) an approximate idea of the depth of the float. The scatter, however, is considerable, and a more accurate method of ascertaining the depth is being developed by lowering two hydrophones on a long vertical cable until they are equally straddled about the transmitter, when there will be no time difference in the received signal.

The float is tracked, usually over two or three days, and its position is plotted relative to some known feature on the sea bed. Fig. 4 shows a typical path of a float loaded for a depth of 400 metres; it shows clear evidence of tidal cycles superimposed on the general north-westerly drift.

INSTRUMENTS FOR DEEP-SEA TRAWLING

Although fundamental research is their primary function, the National Institute of Oceanography also play a large part in the solution of the day-to-day problems of the fisheries, seaside municipal authorities, and others concerned with the sea. For instance, ocean fishermen, having located a shoal in midwater by echo-sounding, need to know the speed and direction of the current at that depth in order to stream their trawls most effectively. For this purpose the N.I.O. have devised a simply-operated instrument known as the Carruthers current cone, which has been developed commercially by Kelvin and Hughes Limited, Barkingside, Essex. This instrument, suitably rigged, is dropped overboard when a worthwhile concentration of fish has been located and is retrieved after about 20 minutes.

The current cone, shown in Fig. 5, is attached to an anchor rope at a distance from the anchor equal to the height of the shoal above the sea bottom, as determined by echo sounding. The anchor rope is maintained in tension by several trawl buoys attached to its upper end, submerged sufficiently to ensure that they are unaffected by wave action. A light line fixed to the top end of the rope is attached to a marker float.

The cone, of perforated aluminium, is pivoted in a fork mounting which is itself free to swivel about the anchor rope on which it is supported by a rope clamp. Thus the cone is free to turn in the direction of the current and to take up an angular position depending on the speed of the current. The latter is determined by measuring the angle between the axis of the cone and a pendulum suspended in PTFE bushes from a quadrant mounted at the open end of the cone. The quadrant carries a scale graduated from 0·1 to 2 knots—a speed range generally sufficient for fishing purposes. (The instrument can, however, be adapted for use in currents up to 5 knots and more by the addition of brass ring weights.)

The current direction, given by the horizontal direction of the cone axis, is measured by a compass card mounted in the base of the pendulum and thus always located in a horizontal plane and maintaining a constant attitude relative to the earth's magnetic field. To preserve the speed and direction indications when the instrument is retrieved, a spring is arranged to clamp the compass and to lock the pendulum to the quadrant by means of a prong which projects through the pendulum base and engages with a rubber strip lining the quadrant. This locking action is brought about as follows: before the instrument is sent down, the locking spring is compressed to release the pendulum and compass and is maintained in compression by inserting a soluble tablet. After some 15 to 20 minutes immersion in the sea, the tablet dissolves and the measuring gear is clamped automatically in the position it has taken up under the action of the current.

The current cone is also useful for research purposes, but in this case it is often more useful to lower the cone from a boat than to jettison it. When operated in this way the pendulum will tend to swing under the action of the waves on the support rope, and the locking gear described above might be unreliable. Instead, the pendulum and compass are mounted in a Perspex cylinder which is filled, before lowering the instrument, with a hot gelatine solution. The latter, setting slowly as it cools, locks the swinging pendulum and the compass in their mean positions. It can be melted again by immersing in hot water.

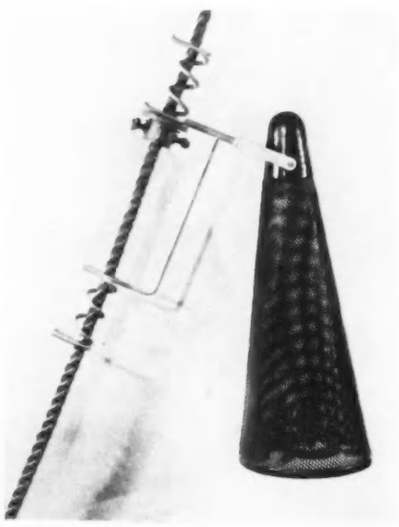


Fig. 5

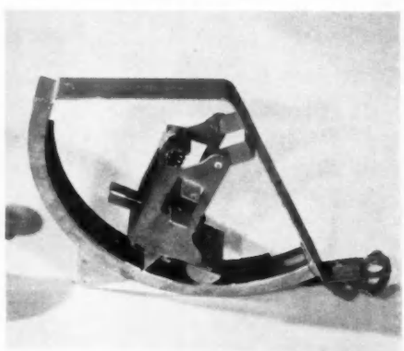


Fig. 6

Figs. 5 and 6 The current cone provides a simple means for deep-sea trawler men to measure the speed and direction of a current at depth.

Fig. 7 Rolling clinometer for measuring the slope and direction in azimuth of towing warps.

In order to know the true height of the current cone above the bottom, it is necessary to take into account the slope of the anchor rope and for this purpose a simple rope-angle gauge has been designed to be fixed to the anchor rope about midway between the anchor and cone. In this gauge a pendulum is suspended between two hinged leaves of transparent plastics material swivel-mounted on the rope. When setting the instrument the leaves, which are spring-loaded to clamp the pendulum, are held apart by means of soluble tablets as in the current cone.

Designed for researches on trawl geometry intended to increase the efficiency of deep-sea trawling, and again developed commercially by Kelvin and Hughes Limited, is a rolling clinometer for measuring the slope and direction in azimuth of the towing warps. This instrument, again, employs a compass and a weighted pendulum in a gelatine-filled Perspex cylinder, but in this case the pendulum and compass are mounted in a frame which itself is free to revolve within the cylinder which is secured firmly to the warp with its axis parallel to the warp. Thus, even if the rope should twist the pendulum is free to hang vertically.

Another angular measuring device for a completely different purpose is the wire angle gauge designed for ascertaining the shape of the deep hydrographic wires—which may extend over several thousand fathoms—used for lowering water bottles for sampling over a range of depths. These gauges, a series of which are clamped to the wire between the sampling bottles, comprise a pendulum in a substantial swinging frame, of tinned brass, and the locking mechanism in this case is mechanical, brought about by the descent of the successive "messengers" which customarily operate the water bottles and reversing thermometers. The operation by the descending messenger of the lever releasing the clamping mechanism also releases a lower messenger to trigger the next bottle or gauge on the line.

BIOLOGICAL TECHNIQUES

Although this article has been concerned mainly with the physical side of the N.I.O.'s work, it should be understood that, hand in hand with the researches on energy circulation and water movements in the ocean depths, go fundamental biological investigations on the

distribution of marine life, the productivity of ocean waters and the biology and life cycle of whales. A recently completed investigation which may have an important influence on fishing techniques has been the study of the effects on fish of direct current, alternating current, and pulsed direct current with a range of frequencies and pulse duration.

* * *

CRANKCASE EXPLOSIONS*

Causes and Prevention

Dangerous circumstances arise when an explosive medium and a source of ignition are present together in the crankcase. The explosive medium is a mixture of lubricating oil in air, which may be mechanically dispersed or the result of condensation of vapourised oil. Spray is always present in a crankcase, but is not known definitely to be explosive. Mist or "smoke" arises only as a result of overheating within the crankcase and is known to be explosive if it is sufficiently rich. The most likely source of ignition is an overheated part, although hot particles discharged past a badly fitting piston ring cannot be completely excluded.

As it has not yet been established whether the oil spray is explosive, it must be assumed that an explosive medium is always present. A detector therefore must sense in advance the development of a source of ignition. Two types have been evolved, one of which relies on the temperature of engine components and the other on the photo-electric detection of condensed mist. Complete protection would seem to be afforded by the provision of suitable relief valves.

Experiments carried out on the ignition of mists by hot surfaces showed that there were two distinct temperature regions where ignition could occur—a result in accord with other experimental work and a specific example of the so-called "low temperature ignition peninsula." The range of the low temperature region depended on the material of the hot surface (phosphor bronze had the largest and brass the smallest) but in general the lower limit was about 270 deg. C. Above this region was a definite space where no ignition occurred until the high temperature region was reached. Ignition delay times in the low temperature region were of several seconds duration, so that it was possible that the air movement in the crankcase of a running engine would prevent any part of the mist being heated up to 270 deg. C. by a hot spot. When the engine was stopped, however, turbulence would decrease and ignition could occur. This probably explains the phenomenon of an explosion occurring some time after an engine showing signs of running hot has been stopped.

Both rig tests and actual engine tests (using an 8-cylinder Sulzer engine) were carried out to determine the efficiency of relief valves. Damage to the engine after the first explosion prevented any tests being carried out while it was rotating, but it was confirmed that it was not possible to get data from an explosion chamber that could be directly applied to a crankcase. In a 200 cub. ft. chamber with a vent area of 3·8 sq. in. per cub. ft., a maximum explosion pressure of 4 lb. per sq. in. gauge was obtained. In a 220 cub. ft. crankcase, on the other hand, with a vent area of 6·1 sq. in. per sq. ft., the maximum pressure recorded was 48 lb. per sq. in. gauge. However, cine films of the tests showed that the relief valves were effective, and that flame traps could prevent the discharge of burning gases into the engine room. Tests were carried out on flame traps of several designs, and it was found that best results were obtained by using internal partition flame traps in conjunction with relief valves fitted with traps of oil-wetted gauze.

* "Crankcase Explosions: an Investigation into some Factors governing the selection of Protective Devices" by H. G. Freeston, J. D. Roberts and A. Thom. "Crankcase Explosions: Development of New Protective Devices" by W. P. Mansfield. Papers presented to the Institution of Mechanical Engineers, April 24, 1956. (Abstracts.)

Institution of Naval Architects Spring Meeting (*continued from page* 343)

STABILITY OF SHIPS

Mr. R. B. Shepheard, C.B.E., B.Sc., took the chair at the second of the technical sessions of the Institution of Naval Architects, on March 21, when Mr. H. E. Steel, C.B.E., Chief Ship Surveyor of the Ministry of Transport and Civil Aviation, delivered his paper on "The Practical Approach to the Stability of Ships."

Mr. Steel's paper traced the developments in the study of stability back to the mathematical investigations of Bouguer in 1746, but, as he pointed out, their practical applications dated from the loss of H.M.S. Captain in 1870 and the capsizing of the Daphne, after launching, in 1883. The Board of Trade issued tentative tables of freeboard in 1875 and Lloyd's Register took stability into account in their rules of 1882. Thereafter, many papers on the subject were read, but it was still felt that stability was a matter for designers rather than for shipmasters. Gradually, this view changed and the circulation of the report of the Bulkhead Committee, the findings of the Second International Safety Convention (1930), and detailed inquiries into various casualties, especially among colliers, stimulated a wider interest in the subject. The Third International Safety Convention (1948) led to the inclusion in the Merchant Shipping Act, 1949, of the requirement that the master of every new passenger ship, and of every new cargo ship of 500 tons gross or more, should be provided with stability information regarding his vessel. An important section of Mr. Steel's paper dealt with typical casualties, and the risks resulting from shifting cargoes; shifting had occurred not only with bulk cargoes such as coal, but with smooth pig-iron, round bars and pipes, steel turnings, stones, sized granite, grain, and even clay in lumps. A troublesome modern risk was found in the products of washings and wet processing; very fine, but relatively heavy, particles of some substances, shipped in a damp condition, displaced part of the moisture towards the surface under the influence of vibration, so that the surface of the cargo assumed a slurry-like consistency, and was then capable of a dangerous free-surface action. Some metallic residues and fine coal washings behaved in that manner and had caused casualties. Dredging craft and crane pontoons presented special problems; and another matter requiring consideration was the effect of water pumped into a ship on fire in port.

The discussion was opened by Professor C. W. Prohaska, who agreed with the author regarding the danger which could arise from hose water between decks during fire-fighting. Mr. Steel had asked whether any members had experience concerning ships which had capsized due to a following sea. This seemed to be proved, so far as it could be proved, in the case of one rather small ship, a cement carrier about 150 ft. long. The holds were full except for part of the fore hold. People in a ship that was following saw that, after rolling 15 deg. to the port side, the vessel suddenly heeled over to 45 deg. to starboard, and went down with all on board. The ship was raised later. The range of stability had seemed sufficient; the metacentric height at the time of the accident was about 17 in. to 18 in.; therefore it seemed extraordinary that the accident should happen. Close investigation indicated that a serious mistake was made in calculation, and the ship had much less stability than the curves would show; the range of stability was not 65 deg., but proved to be only 40 deg. That occurrence emphasised the importance of exact stability calculations for ships.

SYNCHRONOUS ROLLING

Dr. W. Muckle asked if it was possible at the present time to state, for any particular type of ship, what was the minimum stability required, as far as the GZ curves were concerned; and also, as far as initial stability was concerned, in terms of metacentric height. It was very difficult to say whether a ship was absolutely stable or had not sufficient stability. Another question was, could a ship of good initial stability be capsized by mishandling in conditions of synchronous oscillations, even if the cargo was well stowed?

The question whether to use GZ curves or righting moment curves was interesting. His own view was that, dealing with wind moments, the righting moment was the one to consider and also in cases of cargo shifting; but in the rolling of a ship among waves, and in comparing the various conditions of loading, he did not think that the righting moment was the true criterion, because the applied wave moment of the ship was also proportional to the displacement.

Mr. H. S. Pengelly noted the author's remark that, for some years, elementary stability had been a subject of examination for masters and mates. It was his own experience, when serving with the Eastern Fleet during the late war, that Merchant Navy deck officers serving in armed merchant cruisers had a very much better grasp of the stability than did officers of the Royal Navy. Recently he had made a five-month voyage as a passenger in a cargo ship of about 7,500 tons gross; when fully loaded with about 8,000 tons of cargo, the displacement was some 15,000 tons. On the outward voyage superphosphates were loaded at Rotterdam; newsprint from Canada and Newfoundland; tin-plate, grain, canned goods and general cargo from the United States; and hemp from Manila. On the homeward journey there was general cargo from Japan; iron ore (destined for Hamburg), goose feathers, hogs' bristles, canned pork, etc., from China; hemp from Manila; and rubber and tin from Singapore and Manila. He was impressed by the way in which that ship left every port on an even keel, and by her behaviour in bad weather. The worst rolling occurred during a storm when crossing the 180 deg. date line. The ship then carried about 5,000 tons of cargo and rolled about 25 deg. to port and rather less to starboard. He suggested that, for ships of that size and service, flirting with small GMs in order to ensure comfort should be avoided, and that, in any seagoing condition, the GM should not be less than 18 in. and preferably 2 ft.; the maximum GZ should be not less than 2 ft. and should occur at an angle not less than 35 deg., and the range should be not less than 60 deg. There was often confusion about the stability of a ship under permanent list. A ready and approximate guide to stability in such a case could be obtained by moving the base line of the GZ curve vertically to cut the curve at the angle of list. That simple device might give the master some guidance in deciding when safety of life should take precedence over safety of ship, i.e., when to abandon ship.

Professor E. V. Telfer said that the paper would certainly be studied by lecturers in many universities in the teaching and application of naval architecture. It was with the idea of making such use of the paper that he asked the author to change some of his terminology, for the benefit of students who might use his paper. The author was entitled to use the shorthand sign "GZ," but if he used the term "GZ curve," he should delete the term "RM" and use the term he really meant, "righting moment"; otherwise it would be confusing to those who thought in terms of BM, RM and other abbreviations on the elementary diagram of stability. He also stated that "Curves of righting levers, GZ, are very suitable for comparing statical stability between different ships for their ordinates bear substantially a linear relation to the ships' dimensions, whereas the ordinates of righting moment curves, W × GZ, vary approximately as the fourth power of the dimensions." What did he mean? Surely, in geometrically similar ships, the GZ must bear an exact linear relation to the ships' dimensions, and the righting moment must vary exactly as the fourth power of the dimensions.

SMALL SHIPS MOST AFFECTED

Mr. J. M. Murray, M.B.E., said that the paper showed clearly that the problem of stability was the problem of the small ship and not of the large ship; statistics of casualties also bore that out. Fig. 2 showed that, for the small ship, 157 ft. long, the GZ curve for a freeboard of 1·7 ft. was very small. The point really was that a ship 157 ft. long might well have a freeboard of 0·17 ft. and not 1·7 ft. The author had said that, for any ship of similar form and proportions above and below water, a uniform linear relationship applied; but Mr. Murray thought that, coming down from a 470 ft. to a 120 ft. ship, that relationship did not apply. To put it in another way: the quarter deck might have a freeboard of 2 in. With reference to synchronous rolling: about six years ago a small German coaster was lost in the Baltic in moderate weather. It was said that the ship was lost because of synchronism with the waves; but that finding was disputed, and it was stated that it had been impossible to upset a model of the ship by that method.

Professor A. M. Robb, referring to synchronous rolling, recalled that Sir John Biles used to tell of a boat which, anchored off one of the West Indian islands, rolled right round and up again. The crew were quite certain that was the case because, when they awakened in the morning, there was a round turn in all the hammock lashings! He recalled also a coaster which left Plymouth for somewhere east, but never turned up. It was certain that she was

navigating in a quartering sea—the very worst circumstances for rolling—but the Court of Inquiry did not conclude that she had capsized; they were satisfied that the ship foundered because of inadequate freeboard. Their reason for ruling out capsizing and blaming the difficulty of steering in a following sea was that the ship had sailed on the evening of Boxing Day and had been delayed for several hours while the crew were collected from various hostelries.

Mr. Steel had referred to the GZ curve in association with synchronous rolling, but how could he show from any theory of rolling motion—and the theory had some relation to facts—that a ship with a small GM would get into the synchronous condition leading to capsizing ? Cutting down the GM period would increase the period of roll and so reduce the possibility of synchronism. He was surprised by Mr. Steel's faith in GZ curves. Only one thing mattered, apart from the centre of gravity, and that was the height of the metacentre.

ALTERNATIVE CRITERION

Professor L. C. Burrill said that he would have liked to see in the paper a statement that no ship less than 120 ft. long should go to sea in the loaded condition with less than 1 ft. GM. Anything under 1 ft. tended to be dangerous. He would like to hear what Mr. Steel had to say on that point. Mr. Steel's criterion was in terms of GZ curves. Some 25 years ago, he (Professor Burrill) suggested an alternative criterion of stability, which was the percentage of the displacement which would have to be shifted from one side of a ship to the other to give a list of 15 deg. That was a technical consideration which was more difficult for a ship's officer to understand than the simple GM; but if it were allowed to be calculated by the " wall-sided " formula, it could quite readily be added as a second criterion.

Mr. D. J. Doust said that it was unfortunate that the problem of stability was a dynamic one; any parameter of the form used to assess the dynamic behaviour of a vessel in a seaway was merely a convenient yardstick. Such yardsticks, whether metacentric height, freeboard or GZ, varied considerably from one ship type to another, and considerable experience of any one type was necessary before they could be applied with confidence. One of them, not specifically mentioned in the paper, but used extensively on the Continent for trawlers, was Rahola's criterion. It was based on the work done to incline the ship to known angles, and the dynamic lever derived had been found to agree with some results from model experiments conducted at the Ship Division, National Physical Laboratory. It was based on actual ship results and was reliable for trawlers of 100 ft. to 120 ft. between perpendiculars. No doubt, similar methods could be evolved for other ship types. A similar problem had been investigated at the N.P.L., concerned with the side-launched behaviour of various ship types. Some of those results from side-launching might well have a bearing on the present problem. Once the vessel had entered the water, its submerged motion consisted essentially of an angular rotation, the sideways linear motion being very heavily damped. Under such conditions it was concluded that the influence of the form or shape of the vessel had a major effect on the subsequent motion—it was found that the metacentric height of the finer forms could be reduced considerably with safety, but the fuller forms, such as coasters and dredgers, required a much greater critical GM to avoid capsizing; the metacentric height for the same form did not materially affect the angular rotation, once the vessel was fully immersed in the water. As the point of instability was approached, the buoyancy forces which would normally assist in restoring the vessel to the upright were absent, because the vessel was virtually in a wave trough.

Mr. B. Baxter agreed with the author that GZ curves were suitable for comparing the statical stability of different ships, but curves of righting moments for different conditions were more convenient for individual ships; but the Ministry of Transport Notice M.375, which dealt with the carriage of stability information, stated that curves of statical stability should be derived from the cross curves. That presentation of the results could be misleading to a ship's officer, particularly if all the curves were drawn on one diagram. The curves of statical stability were drawn for a poop, bridge and forecastle type of vessel 310 ft. between perpendiculars, 46 ft. 4 in. in moulded breadth and 25 ft. 2 in. depth moulded to the upper deck. The difference between the maximum values for GZ was marked, but the disparity was reduced considerably when the righting moments were considered. He thought that a strong argument could be put forward for the inclusion of the free-surface correction at all angles of inclination when dealing with normal ship conditions.

He asked the author the following questions: What was the minimum safe value for the GM of a ship when in the worst service condition ? How were the curves of statical stability for different types of ships compared ? When carrying a deck cargo of timber, what allowance should be made for water absorption during a voyage ? What allowance should be made when carrying esparto grass ? What growth was usual in the light-ship weight of ordinary cargo ships per year ? The cross curves of stability for the Empire type of ships were drawn with the initial assumption that the KG values were 6 ft. Nobody had been able to explain to him why such a very small value for KG was assumed. Did Mr. Steel know the answer ?

WARSHIP PRACTICE

Professor S. J. Palmer, O.B.E., questioned the wisdom of designing merchant ships with small metacentric heights. The usual argument in favour of doing so was that a low GM led to long-period rolling, which was more comfortable than the short-period rolling obtained with a high GM. In general, that was not true. In the irregular waves met at sea there were usually components whose lengths varied from very short to very long, and a ship responded most to the components in resonance with its own natural period. A moderate change in natural period would not allow the ship to escape the possibility of synchronous rolling with some components of the irregular sea. Again, the ship might be steaming at any angle to the waves and there would be one course on which the period of encounter of the maximum component of the irregular sea would synchronise with the ship's natural period, whatever that might be, within wide limits. If warships were compared with merchant ships, there was a striking difference between their metacentric heights, because warships usually had between 3 ft. and 6 ft. in the deep condition, to give enough stability after damage by enemy action; but warships were usually quite comfortable with those high GMs. He suggested, therefore, that there was no justification for low GMs; larger values would give a greater safety margin, would lessen the need to ballast, and would not lead to an appreciably less comfortable roll.

Mr. Steel, replying to the discussion, did not think that there was any authentic information of a ship capsizing synchronously. He had heard of two fishing boats which capsized completely and came up the other side. In one case the mast was broken, and in the other the vessel carried on. Those instances occurred in the Icelandic area. Of other reported cases, he knew something about the Danish ship and had some recollection of the German ship, but he did not think that the evidence was quite firm. Quartering seas were dangerous, and so was synchronism. The effect of a quartering sea might be to alter the condition of the ship, either through shift of cargo or through opening her up in some way. He agreed with what had been said by Dr. Muckle and others about the uses of righting moments and GZ. When examining a large number of stability curves for many ships, by looking at a GZ curve a picture was obtained for a particular type. When dealing with righting moments, displacement came into it to such an extent that a quick comparison was not possible between two ships of a similar type; but the investigations he had mentioned, using righting moments, were the analyses referred to in the paper.

If he had attempted to lay down a standard for stability, as suggested by Mr. Pengelly, he would be shot at by Merchant Navy architects. What he had said was that a ship could be safe with fairly small calculated stability provided every other precaution was taken. He had not attempted to deal with the designers' questions; the paper was intended to promote safety in ships. As to the absorption of water by timber, esparto grass, and so on, there were figures; but timber varied a great deal, and the law left it to the masters to determine the type of cargo they carried. He agreed with Professor Palmer that low stability was not good, and he was not sure that all oceangoing ships ran with as large a GM as they might. On 90 per cent. of the voyages they might be quite safe, but in a severe storm, if the cargo or bunkers or something else shifted and there was a breakdown in any of the fittings, a ship might get into difficulty. A good GM, which the master should be able to judge according to his vessel, was an insurance against something going wrong.

Report of meeting to be continued

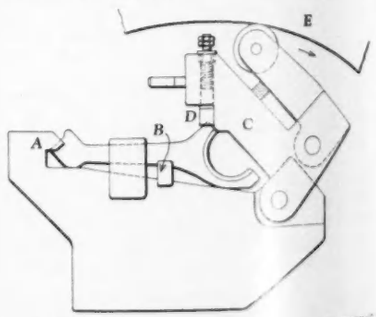
GRINDING CONNECTING-ROD AND CAP SIDES

Special Work-Carrier on Duplex Grinder

The duplex surface grinder, employing two coaxially mounted grinding wheels with their cutting faces parallel, can be used for simultaneous grinding of opposing faces of many different types of component. Stock removal can be heavy when required, and the machine will work to close limits of accuracy. To pass the components to be ground between the grinding wheels it is necessary to have a work-carrier of suitable design. Such a work-carrier, designed by Arthur Scrivener, Limited, Tyburn-road, Erdington, Birmingham, 24, for use with their horizontal duplex surface grinder, is shown in the accompanying illustrations.

It consists of a power-rotated disc, the axis of which is parallel with, but in front of, that of the two grinding heads. On the periphery of the disc are fixtures for carrying connecting rods and caps; they are arranged alternately and each is equipped with a spring-loaded clamping arm and suitable location points. A connecting-rod forging is placed in position against the two location V's, A and B, as shown in the sketch, and the clamping arm C is swung into place manually to register with the third V, marked D in the sketch.

The work-carrier rotates slowly (from 1 to 3 r.p.m. under the control of a variable-speed gear), and each fixture in turn comes under a cam-ring E, which, by means of a roller on the fixture, applies the pressure of a helical spring between C and the roller arm so as to hold the component in position while it is ground. As rotation continues, the fixture passes clear of the cam-ring, and the clamping arm opens to allow the connecting-rod to fall into a chute. A similar fixture is used to carry the connecting-rod cap.



(35/8.6.) "ENGINEERING"

A special work-carrier can be fitted to the Scrivener duplex horizontal surface grinder to enable it to deal with connecting rods and caps.

Book Reviews

FLUIDS IN MOTION

Boundary Layer Theory. By HERMANN SCHLICHTING. Translated by J. KESTIN. *Pergamon Press, Limited, 4-5, Fitzroy-square, London, S.W.1.* (105*s.*)

The viscosity of a fluid is one of its most important physical properties. In any non-uniform motion of a gas or a liquid there is friction—arising from molecular transfer of momentum—and the coefficient of viscosity relates the stress to the rate of strain analogously to the Young's modulus of solid mechanics. There are, however, many aspects of fluid motion which can be calculated quite accurately by neglecting friction altogether. These theories are of value if the effects of viscosity in slowing down the motion are confined to a thin region very near the body and to a narrow wake, but it would be impossible to forecast whether this restriction applies in any given motion unless one has a thorough knowledge of the balance of forces in this so-called boundary layer which "grows" at the skin of any solid that is in contact with moving fluid.

We may consider a particle of fluid near such a surface. Its momentum tends to be reduced by shearing action—since we may expect the shear stress (friction) to be greater on the side near the surface—while the action of streamwise static pressure gradients may enhance or reduce this momentum. These effects diffuse outwards in proportion to the value of the coefficient of viscosity. When the motion is very slow they diffuse indefinitely far away from the body, and there can be no question of defining a "boundary" layer outside which there are no effects of friction. When the velocity of streaming is large, however, the above effects may be convected downstream at a greater rate than the rate of outward diffusion. It is then possible to define a boundary in the fluid outside which the effects of friction are negligible. Mathematically speaking, one can always find a region in which the "viscous terms" of the equation of motion are of the same order as the inertia terms. For fast motion or small viscosity this region is narrow and the boundary layer concept becomes useful. It was proposed by Prandtl in 1904. The accuracy of calculations of lift and drag of aerofoils depends on a reliable knowledge of what goes on in this region and it is not surprising to find that the main advances in this field have been made in response to the demands of aeronautical engineering.

Professor Schlichting is responsible for some of the essential forward steps which have taken place during the 50 years that are covered, and he has made a brilliant job of this text-book. It is the only one of its class available in English. The reviewer knows that it already finds a place in all aeronautical libraries and on many private shelves but he would like to stress the value of this fundamental work to engineers in the fields of mechanical, chemical and atomic engineering. Turbines, rotary compressors and heat exchangers in which there is motion of one or more fluids may all run at very much reduced efficiency if the design is not aimed at keeping the boundary layer in check. An attempt has been made to bring theoretical considerations into a form which can be grasped by engineers and is, on the whole, successful. Those experimental results which are quoted have been chosen for their suitability to give a clear physical insight into the phenomena and to provide direct verification of the theory presented. The reader is thus relieved of the struggle through the empirical morass that is often called for.

The first two chapters form a non-mathematical introduction to the subject; the distinction between real and "perfect" fluids is carefully drawn, and it is shown how the condition of no slip at boundaries leads to great differences in flow even for fluids with vanishingly small viscosity. The viscosity is introduced in Newton's manner rather than in Maxwell's, which is wise since the physical significance of the viscous normal stress terms in the Navier-Stokes equations can only be explained in terms of molecular momentum exchange, but this is perhaps an over-subtle teaching point. There are fine pictures of boundary layers separating to form vortices and also of Prandtl's experimental use of suction slots to delay separation in wide angle diffusers. It is embarrassing to note that this "modern dodge" of boundary layer control was successfully tried before the first World War. The next three chapters are concerned with the derivations, the general properties and the few known exact solutions of the Navier-Stokes equations of laminar motion. The derivation is neat, but practising engineers will want to consult their mathematical friends on seeing the stress and strain tensors. They will be assured that tensor algebra is not used but that the tensors occur in order to make certain groups of terms look more orderly. After all, stress is tensorial in nature just as force is vectorial. It is one of the beauties of the work that the unphilosophical reader can utilise the later chapters without first battling through this derivation. The work of Stokes, Oseen and Hele-Shaw is dealt with in a chapter on "Very Slow Motion." The hydrodynamic theory of lubrication is included here, and it is clearly illustrated by a two-dimensional example.

The boundary layer approximations to the full equations of motion are introduced in Chapter 7 for two-dimensional incompressible flow. The physical essentials underlying the neglect of certain streamwise derivatives are never lost sight of, and pass graduates should feel quite at home here. General properties and exact solutions of these approximate equations are covered in the two succeeding chapters. A solution is given for the development of a laminar jet issuing from a slit; the boundary layer approximations apply to this case as well. A chapter on steady three-dimensional boundary layers includes the following topics; axially symmetrical boundary layers on bodies at rest, the circular jet, the yawed cylinder (not necessarily circular), boundary layers on rotating bodies. Chapter 11 is concerned with unsteady motion, i.e., motion in which the velocity and other quantities at a fixed point vary with time. No great progress has been made with such unsteady phenomena as the starting motion of a cylinder, but periodic boundary layer flows are treated and used to explain the dust patterns found in Kundt's tube experiments.

The convective inertia terms which occur in the Navier-Stokes equations and also in their boundary layer approximation are non-linear, and it is surprising that a considerable number of exact solutions exist. Nevertheless when it comes to the calculation of the growth of a laminar boundary layer in, say, a given wind-tunnel contraction or near the nose of a given aerofoil, one will not be able to draw on an exact solution that applies. This is where the v. Kármán-Pohlhausen momentum approach comes to aid. The equations of motion are no longer satisfied exactly, but only in the mean. An arbitrary velocity distribution is assumed but care is taken to ensure that the corresponding momentum flux is properly equated to the net force arising from the skin friction and the static pressure gradient. Any exterior pressure distribution may be introduced, but it is found that the method is very inaccurate when the pressure rises in the direction of motion. Thwaites in this country discovered the essential properties of the velocity distribution in laminar boundary layers and introduced the corresponding data from all known exact solutions into the Kármán momentum equation. The resulting formula for the thickness is a simple integral and this has been widely used since 1948. The formula can also be used to predict the point of laminar separation and naturally agrees better with exact solutions (which it uses) than Pohlhausen's. The German edition made no mention of this in the chapter (12) devoted to approximate methods but one is glad to note a grudging paragraph devoted to the Thwaites formula on page 220!

Boundary layer control is given an adequate survey in Chapter 13. Again one is sobered by the mention of a pre-war German aeroplane equipped with boundary layer suction on the wings. Is this a field where others have made the fundamental scientific advances while we work on the technological exploitation? Let us hope so. The chapter would have been more representative if some mention had been made of the extensive Australian work in this field.

"The transfer of heat between a solid body and a liquid or gaseous flow is a problem whose consideration involves the science of fluid motion. On the physical motion of the fluid there is superimposed a flow of heat and, generally speaking, the flow field interacts with the temperature field. In order to determine the temperature distribution it is necessary to combine the equations of motion with those of heat conduction." This is the opening of Chapter 14 on "Thermal Boundary layers in laminar flow"; a very satisfactory chapter that introduces us easily to the Prandtl, Grashof, Nusselt, Peclet and other numbers which have to be understood if the subject is not to remain an empirical jungle for the reader. The next chapter on "Boundary Layers in compressible flow" is rather thin, but reference is made to Professor A. D. Young's survey written in 1953. It is probably true to say that in the absence of shockwaves the effects of compressibility are nothing like so profound on the flow in the boundary layer as they are on the external flow. Yet the calculation of boundary layer properties becomes much more difficult since the heat due to friction as well as that due to compression must be taken into account. Moreover the coefficient of viscosity must be expressed as a function of temperature. The fundamental work of Holder, Gadd and others at N.P.L. on the so-called shock wave-boundary layer interaction problem appeared too late for inclusion in the book.

The next nine chapters are devoted to turbulence, its origin, and turbulent flow in boundary layers, wakes, jets and pipes. Few scientists could be better qualified to write on this subject than Professor Schlichting who in 1935 collaborated with Tollmien to produce the famous small perturbation theory of the stability of laminar boundary layers. This was not believed at the time and the crucial confirmatory experiments of Schubauer and Skramstad (1940) remained classified until after the war. It is perhaps to make up for this that we are given two quite heavy chapters on the stability of laminar layers with various pressure gradients, heat transfers and suction. The basic original work of Reynolds and Lord Rayleigh is properly acknowledged. The last seven chapters take us systematically through the following and other topics: Reynolds' stresses, mixing length and eddy viscosity theories, Sir Geoffrey Taylor's vorticity transport theory; v. Kármán's similarity hypothesis; turbulent flow through pipes and universal resistance law for very large Reynolds' number; skin friction drag of smooth and rough flat plates, rotating discs; admissible roughness on aerofoils, turbine blades, etc.; calculation of development of two-dimensional turbulent boundary layer in an arbitrary pressure field (no mention of Maskell's able work); free turbulent flows; profile drag of aerofoils, and losses in cascades.

The reader who has digested the contents of "Boundary Layer Theory"—and perhaps some of the 794 references to books and papers—will not need much dessert. The recently published proceedings of the N.P.L. symposium on "Boundary Layer Effects in Aerodynamics," H.M.S.O., 1955, will be quite enough to bring even specialists right up to date. The printers—G. Braun of Karlsruhe—have made an excellent job of the production, the author's assistants have indexed the volume very carefully and Dr. Kestin's translation has rendered the heavily Germanic original into a most readable piece of technical prose.

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Local Instability Problems of Light Alloy Struts. By P. S. BULSON. Research Report No. 29. *The Aluminium Development Association*, 33 *Grosvenor-street, London, W.*1. (7*s.* 6*d.*)

This report describes an investigation forming part of the programme of the A.D.A., and, in this instance, carried out under the direction of Professor A. G. Pugsley at the University of Bristol. It deals with the efficiency of aluminium alloy structures and components in which strength is governed by some form of instability, rather than theb reakdown of the material. This is particularly important in light-alloy design because the freedom of form allowed by the extrusion process has enabled sections to be made with thinner walls and wider flanges and also because of the low value of Young's modulus. The book opens with a survey of existing work, followed by a statement of the scope of the investigations described and a detailed account of the theory upon which the experimental work described in the next section depends. Test results are then given under two subheadings: maximum local instability stresses, and strut curves. The main part of the report concludes with a discussion of results. An appendix gives the mathematics for the stability of a single flat plate under known edge conditions.

Teach Yourself Perspective Drawing. By H. F. HOLLIS. *English Universities Press, Limited*, 102 *Newgate-street, London, E.C.*1. (6*s.*)

Though of considerable value as a means of clarifying the design of a component represented by standard orthographic projections, the isometric drawing cannot give as faithful a picture as a perspective drawing. (A perspective drawing is " a true representation on a flat plane of the appearance of an object seen from a specific viewpoint.") In many cases such a drawing may be useful in visualising an engineering product and the greater complexity of drafting justified. This book, which is one in the popular " Teach Yourself " series, gives a full account of the theory and practice of perspective geometry and though primarily intended for artists and architects may prove also of interest to engineering draughtsmen.

Applied Electricity. By A. W. HIRST. Third edition. *Blackie and Son, Limited*, 17 *Stanhope-street, Glasgow, C.*4. (25*s.*)

The third edition of this book, which was first published in 1942, has been written with the syllabus of Part I of the London B.Sc.(Eng.) examination in view. Rationalised M.K.S. units have been used throughout and form the subject of an introductory chapter. The other chapters deal with direct-current machines; alternating-current circuits; transformers; alternators and synchronous motors; the induction motor; conversion of alternating to direct current; transmission, distribution and utilisation; illumination; instruments and measurements; materials; and the elements of thermionics. A good deal of new material has been inserted and the number of examples has been increased.

Better Ways: Nineteen Paths to Higher Productivity. *British Productivity Council*, 21 *Tothill-street, London, S.W.*1. (2*s.* 6*d.*)

The plan followed in this " primer of productivity " is to describe some of the main techniques or methods in short chapters and then to illustrate each by one or more case studies showing how they have been used in leading firms. The nineteen paths referred to in the title are discussed under the following chapter headings: what work study means; method study; work measurement; job evaluation; wage incentive schemes; process study; product selection and design; the " Three S's " in industry (simplification, standardisation and specialisation); layout and handling; production control; stock control; budgetary control; statistical methods in industry; quality control; planned maintenance; joint consultation; information for workers; and staff selection and training. The booklet is well illustrated.

Catalogue of Nuclear Reactors, 1955. Prepared by Atomic Energy of Canada, Limited, with the co-operation of the Atomic Energy Research Establishment, Harwell. *H.M. Stationery Office, Kingsway, London, W.C.*2. (4*s.* 6*d.*)

At the International Conference on the Peaceful Uses of Atomic Energy held in Geneva last August, considerable information was released concerning the nuclear reactors which various countries had already brought into operation. These details together with other published data on the subject have been used to compile a catalogue of nuclear reactors known to have reached criticality by July 1955. The reactors are classified in terms of neutron speed, fuel configuration, kind of moderator, purpose, thermal power and neutron flux; and in some cases, the properties and construction of the reactor are given in detail. Other features described are : reflector, coolant, shielding, size, temperatures, control system, experimental facilities and estimated cost. A complete page is devoted to each reactor, and the contents of the catalogue are tabled both alphabetically and geographically; additions and revisions will be issued from time to time. (Readers may be interested to note that an article including a tabulated analysis of all the reactors described at the Geneva Conference including unfinished and projected reactors, appeared in ENGINEERING on October 7 last year; some copies of the second reprint are still available).

Fifth Symposium (International) on Combustion: Combustion in Engines and Combustion Kinetics. Published for the Combustion Institute, under the auspices of the Standing Committee on Combustion Symposia, by *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (15 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (120*s.*)

The fifth international Symposium on Combustion was held in Pittsburgh, from August 30 until September 3, 1954, and of the papers presented 101 have been selected for publication in the above volume. Believed to be the most thorough and authoritative survey of combustion problems up to that date, it includes sections on the kinetics of combustion processes, the combustion of fuel droplets, propellant burning, combustion of solids, diffusion flames and carbon formation, flame spectra and dissociation energies, combustion in engines, and a number of special techniques; there is also a report of the panel discussions. The book, which is well illustrated, contains a comprehensive table of contents and a list of authors.

Cedar Bluff Dam. Technical Record of Design and Construction. *United States Department of the Interior, Bureau of Reclamation, Denver, Colorado.* (No price given.)

The Cedar Bluff Dam is a key feature of a multi-purpose development project situated in Ellis County, Kansas. The dam is a rolled earth structure, approximately 12,500 ft. long and nearly 200 ft. high at the maximum depth. Its spillway has a maximum discharge of 87,400 cub. ft. per second. This report is a full technical record of the design and construction of the dam and particular problems encountered arising from the extreme and sudden changes of weather which occur in the area. Floods, tornados, hail storms and dust storms are not uncommon and the variation in river flow, which depends largely on rainfall rather than snow-melt, fluctuates widely and occurs at unpredictable times.

The Strength Properties of Timber: The 2-CM Standard for Tests of Small Clear Specimens. By F. H. ARMSTRONG. Forest Products Research Bulletin No. 34. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

It has been the regular practice in the United Kingdom to use specimens of 2 in. square cross-section for all tests made on timber. Continental practice, on the other hand, has made use of specimens only 2 cm. square in cross-section. The Forest Products Research Laboratory has recently made an investigation employing the smaller size of specimen, and data from tests made on 29 hard woods and 12 soft woods are given in this report. Comparisons are made between the information gained from tests on specimens of both sizes.

Films in Human Relations. *Scientific Film Association*, 164 *Shaftesbury-avenue, London, W.C.*2. (2*s.* 6*d.*)

The industrial committee of the Scientific Film Association organised a conference at Ashorne Hill from May 24 to May 26, 1955, on " Film in the Improvement of Human Relations in Industry " and this booklet is a record of the proceedings. It contains the introductory address of Sir Godfrey Ince, G.C.B., M.B.E., and the text of other speeches dealing with the use of films as means of instruction, explanation, introduction, communication and exhortation in industry. A list of the organisations represented at the conference, the conference programme and some details about the Scientific Film Association are included.

Works Structures. By R. F. MILES; and **Corrosion Problems Relating to Works Structures.** By C. W. MARLER. Proceedings No. 31. *The Fertiliser Society*, 44 *Russell-square, London, W.C.*1. (12*s.* 6*d.*)

These two papers were originally read before the Fertiliser Society in February, [illegible], and are now published together in book form. The first paper " Works Structures " is a concise examination of the problems that are encountered when selecting building forms for industrial purposes and when choosing the covering materials. No attempt is made to discuss design in detail, though attention is drawn to the importance of a thorough site investigation. The second paper is concerned with the mechanism of corrosion and its effects on different materials, with particular reference to the selection of constructional materials for use in industrial atmospheres and the different treatment they can be given in order to extend their useful life.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given though distribution is sometimes restricted.

Training Electrical and Mechanical Engineers. THE BELMOS CO. LTD., Bellshill, Lanarkshire. Training facilities offered by the company for training electrical and mechanical engineers of craft, technical and professional standards in switchgear and other control equipment. Details of courses, working hours, holidays and amenities. Illustrated booklet. Enquiries to Mr. J. Martin care of the company.

Electricity in the Home. BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION, 2 Savoy-hill, London, W.C.2. Talkiestrip, " The Need for Knowledge, No. 1 " for instructing sales staff in answering problems of domestic users of electrical equipment generally. Film, " Emney's Electrical Enterprises," designed to promote interest in immersion heaters and other electric water heaters.

Brickwork. LONDON BRICK CO. LTD., Africa House, Kingsway, London, W.C.2. " Phorpres " bricks for external facing walls, and clay blocks for load-bearing walls and partitions. Coloured illustrations showing texture and patterns obtainable with different facing bricks. Data on standards specials, etc. Also technical notes on construction, etc. Illustrated booklet.

Two-Man Chain Saw. J. CLUBLEY ARMSTRONG DANARM LTD., Abford House, Wilton-road, London, S.W.1. Addition to range of electric and petrol-driven chain saws is the two-man petrol driven version which will make cuts up to 7 ft. in diameter. Cutting speed 18 sq. in. per second in dry elm. Peak rating 11 b.h.p. at 3,000 r.p.m. Leaflet.

Electric Tools. WOLF ELECTRIC TOOLS LTD., Pioneer Works, Hanger-lane, London, W.5. Portable saw, type RS10 and 6 in. heavy-duty grinder, also belt sanding attachment for mounting on grinder. Specification sheets and notes of unusual applications, particularly in building operations. Illustrated leaflets.

Painting Stonework. CORROSION LTD., 16 Gloucester-place, Portman-square, London, W.1. " Glocrete Stucco," a paint with a base composed of synthetic rubber, suitable for covering concrete, bricks, plaster and other building surfaces. Resistant to acids and chemicals; also weathering properties. Information leaflet.

Remote Control Stations. THE BELMOS CO. LTD., Bellshill, Lanarkshire. Control desks and pedestals for floor-mounting. Stations for wall-mounting. Push button equipment for operating starters, where these are installed near the motors and control is effected from a central position. Descriptive illustrated leaflets.

Practice of Advertising. INSTITUTE OF PRACTITIONERS IN ADVERTISING, 44 Belgrave-square, London, S.W.1. " In the Interest of the Advertiser," booklet explaining qualifications and standards of conduct of member agencies; points in selecting an agency; and services offered by the Institute.

Generating and Welding Plant. PETROW LTD., Sandwich, Kent. First bulletin of a series intended to give news of the firm's developments and new products. Items mentioned include portable generating sets; stand-by plant; engine starters and welding equipment.

Fractional Horse Power Motor. BROOK MOTORS LTD., Empress Works, Huddersfield. The " Merlin " motor for light industrial or domestic uses. Light compact fan ventilated. Made in three sizes, $\frac{1}{6}$, $\frac{1}{4}$ and $\frac{1}{3}$ h.p. Leaflet.

Conveyor Belt Idlers. GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2. Heavy duty idlers for conveyor belt systems: steel tube troughing type or rubber disc type. Illustrated booklet No. 2829.

LIGHT GAS TURBINE

VERSATILE AUXILIARY POWER PLANT

Aero-engine and large-scale industrial applications of the gas turbine have tended to overshadow its development as a light-weight prime mover, so that its more modest use in fire pumps, auxiliary generators and similar equipment is often overlooked. However, with the advent of the gas-turbine car the position may be changed. Recognising the need for a light simple engine, Mr. D. D. Budworth of David Budworth Limited, Harwich, Essex, has developed a small 45 to 60 h.p. gas turbine, approximately 16 in. in overall length and weighing only 45 lb., without reduction gearing, for applications ranging from pumping to the propulsion of high-speed boats. Figs. 1 and 2 show a general view and sectional drawings of the unit.

The history of the turbine is of considerable interest. Mr. Budworth started building the prototype in 1950 but before it was completed he attended a course at the School of Gas Turbine Technology, Farnborough (see Weekly Survey). The original model, made entirely of fabricated mild-steel components, was fully self-sustaining but with a considerable volume of exhaust smoke and flame. Owing to the very poor combustion, this first engine never reached its design speed. Very limited facilities were available to Mr. Budworth at that time so that it was impossible to do any separate component testing, and the combustion had therefore to be good enough to give full-speed running before any estimate of compressor and turbine performance could be obtained. The first prototype was soon discarded in favour of a slightly more refined version, which made use of aluminium castings and had a properly built-in starting unit. Two of these engines were made and the combustion system worked sufficiently well for full speed to be reached.

Since then gradual refinements in all the component parts have been made, but it was not until last year that the full output of 60 h.p. was achieved. As with all gas turbines the engine is now capable of a very great temporary increase in power over that at which it is rated. During development the eventual manufacturing costs have been continuously kept in mind together with the importance of retaining the basic simplicity in design.

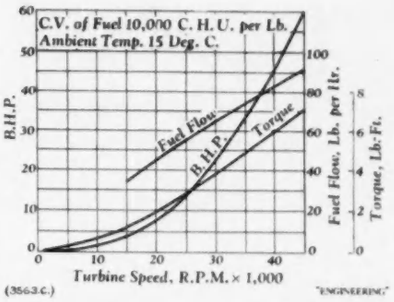

Fig. 3 Performance curves for the Budworth gas turbine (b.h.p., torque and fuel flow). A low-pressure fuel system is used so that the pressure inside the combustion chamber has only to rise slightly with speed to cut off the fuel supply, and conversely. This simple method of governing can be replaced by a centrifugal governor.

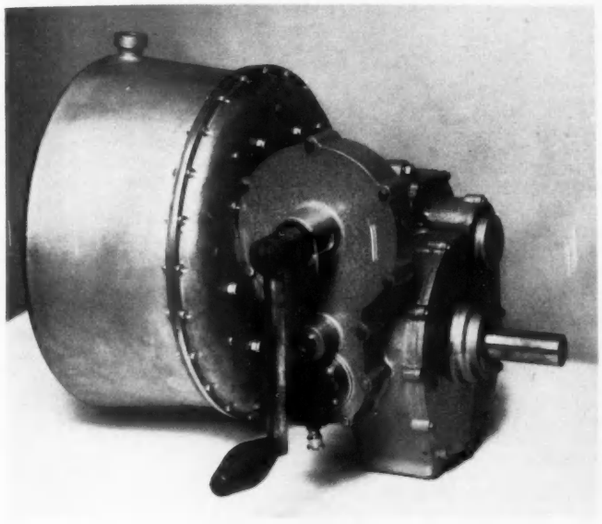

Fig. 1 The Budworth gas turbine, which develops from 45 to 60 h.p., weighs only 45 lb. and is approximately 16 in. in length without reduction gearing. It can be used for applications ranging from auxiliary power generation and pumping to the propulsion of speed boats.

ESSENTIALLY SIMPLE DESIGN

The engine is the simplest type of gas turbine and has been designed for portable and auxiliary power requirements where light weight, simplicity, and ease of operation and maintenance are of prime importance. It can be coupled to a 15 : 1 reduction gear as shown in Fig. 2, but as an alternative, a 20 : 1 bevel reduction gear can be fitted, which is more convenient for some purposes. The weight of the complete unit including compound helical reduction gear varies from 60 to 100 lb., depending on the application. The turbine speed is 45,000 r.p.m. which gives an output shaft speed of 3,000 r.p.m. with one reduction gear and 2,250 r.p.m. with the other.

As can be seen from Fig. 2, the turbine unit consists of an annular combustion chamber surrounding a radial compressor and turbine mounted back-to-back on the same shaft. On leaving the diffuser, the air is divided into three

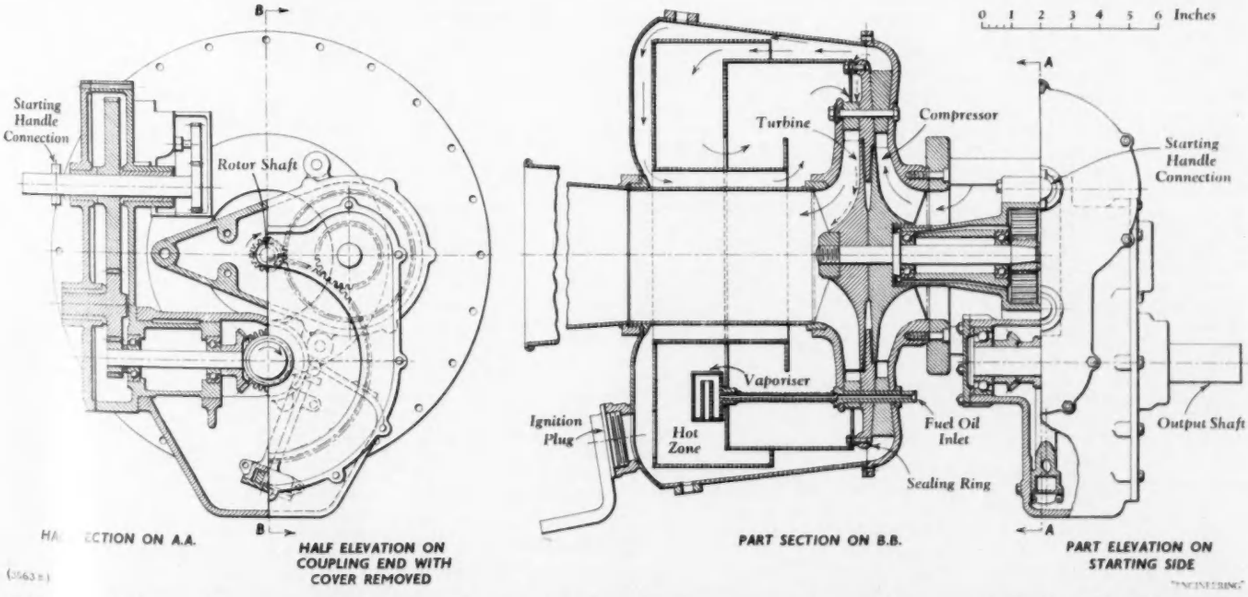

Fig. 2 Simplicity is the keynote of the Budworth engine, drawings of which are shown here. The unit is symmetrical and consists of an annular combustion chamber surrounding a radial compressor and turbine mounted back-to-back on the same shaft. Cooling is effected by dividing the air flow into three streams as indicated by the arrows: two are for cooling and the other provides primary combustion air.

streams as indicated by arrows on the drawing. The outermost stream keeps the casing of the combustion chamber cool and also cools the exhaust pipe and face of the turbine nozzle ring; the middle stream provides air for primary combustion, while the inner one cools the face of the turbine rotor. The design is entirely symmetrical about the turbine axis and the combustion chamber is supported solely from three legs on the reduction gear case. This symmetrical arrangement and freedom of movement reduces any likelihood of trouble from unequal and restricted expansion.

A low-pressure fuel system is used, such that the fuel pressure is only a few lb. per sq. in. higher than that of the combustion chamber. The pressure inside the combustion chamber has only to rise a very little with speed for the fuel supply to be cut off altogether, and conversely with a small drop in r.p.m. This method of governing is extremely simple and is sufficiently accurate for all except some power-generation applications, in which case a centrifugal governor can be fitted. Any distillate fuel may be used and the consumption of gas oil is between 10 and 12 gallons per hour. Performance curves for the engine are given in Fig. 3.

It can be used for driving fire and salvage pumps, auxiliary generators, hydraulic pumps, and other equipment aboard ships and is also suitable as a propulsion unit for high-speed boats. A range of suitable lightweight all-aluminium pumps are made for use with the engine with capacities from 450 gallons per minute for fire fighting, to 4,500 gallons per minute for salvage work.

ROYAL SOCIETY CONVERSAZIONE

APPLIED ELECTRON MICROSCOPY

The Royal Society's annual conversazione was held at Burlington House, London, W.1, on May 10, the Fellows and guests being received by the President, Sir Cyril Hinshelwood. In accordance with custom a number of exhibits of scientific interest were on view, a feature being the comparatively large number in which electron microscopy played a part. Engineering, as such, received little direct representation.

Among the historical apparatus, great interest was taken in the equipment used by J. J. Thomson at the Cavendish Laboratory, Cambridge, in "discovering" the electron and measuring its properties. The technique of "sealing wax and string" used by this great scientist was much in evidence and showed his capacity for rapid improvisation.

SYNTHESISING SPEECH

The Post Office Research Station demonstrated a method of analysing and synthesising speech, which seems to have considerable promise. The loudness of vocal sounds of a humming and hissing character and also of the pitch of the humming sounds are examined in an electronic analyser, and the positions of the resonances or "formants", which turn these inarticulate noises into speech and move continuously up and down the frequency scale, are also measured. If similar resonances are introduced into a synthesiser at the other end of a telephone line, speech sounds can be reproduced. Although the system is only experimental at the moment it is hoped that acceptable commercial quality may eventually be obtained and that the control signals passing between the analyser and synthesiser will be many times simpler than those in ordinary telephony.

The Post Office Research station were also showing apparatus known as the "compandor," which is designed to eliminate noise and cross-talk on telephone systems. It consists essentially of a compressor and expander, each of which adjusts its amplification according to the loudness of the speaker's voice. The compressor, which sends speech into the system, has maximum amplification for quiet speech, thus ensuring that all signals are of reasonably higher level and louder than the interference. The expander has least amplification when no speech is present so that noise is inaudible. When, however, a signal arrives its amplification increases in step with the decrease in the compressor, thus restoring the original speech level.

SILICON AND GERMANIUM CRYSTALS

The Solid-State Physics Section of the Research Laboratory of Associated Electrical Industries Limited, Aldermaston, showed a film illustrating the purification and growth of perfect crystals of silicon and germanium. They also exhibited a collection of monocrystals of these materials, in the form of both ingots and dendrites, to show the various types of defects, while a number of demonstrations were given to display the electrical, optical and thermal effects of p-n junctions especially as a solar battery. A model of Merlin (medium energy research light motor-moderated industrial neutron) reactor which is to be installed at Aldermaston was also on view. It will be constructed by A.E.I.-John Thompson Nuclear Power Company, Limited, and should be critical about the end of 1957.

THE ELECTRON MICROSCOPE IN BIOLOGY

How crystal lattices can be directly observed and their imperfections studied by the electron microscope was demonstrated by Mr. J. W. Menter, Tube Investments Research Laboratories, Cambridge. He shows that with favourable specimens detail of dimension less than 0·0000001 cm. could be viewed compared with 0·0002 cm. with the conventional light microscope. Electron micrographs of coccolithophorids, minute algae which live abundantly in the upper level of the sea and are of importance as food to filter-breeding organisms, were exhibited by the Mineralogy Department of the British Museum and the Department of Applied Physical Chemistry, Imperial College of Science and Technology. Here again the increased resolving power of the electron microscope is of great value. Useful information about the way in which the surface membranes of nerve and muscle fibres are related can also be obtained by electron microscopy, as was shown by the exhibit of Dr. J. D. Robertson, University College, London.

COAL STRUCTURE

Among the problems which coal presents both to the fundamental and applied scientist is that of its atomic structure. As demonstrated by Messrs. L. Cartz, R. Diamond and P. B. Hirsch of the Cavendish Laboratory, Cambridge, this can be determined by the study of the X-ray scattering from samples. It is found that each sample contains sheets or "molecules" of carbon atoms which are packed parallel to each other in small stacks. Different types of coal are characterised by different average molecular diameters and by different degrees of order in the stacks. When a coal is heated *in vacuo* to make a coke, the sheets join up to form larger molecules and by following the changes in the distribution of sizes with the temperature it is possible to obtain a picture of the structure of cokes and of the mechanism of its formation.

INSECT IN FREE FLIGHT

The Agricultural Research Council Unit of Insect Physiology, Zoology Department, University of Cambridge, showed an apparatus for studying insects in free flight, which has made it possible, under laboratory conditions, to investigate the effect of flight on high-level nervous co-ordination of the insect.

In this apparatus, flight is maintained by balancing the insect's attraction to light against an air jet, the speed of which must be continuously adjusted to compensate for changes in the insect's rate of climb towards the light. The air-speed control mechanism is coupled to a pen-arm, thus providing a continuous record of the strength of flight response. The same pen also serves to record the strength of the insect's response to a "host" leaf after it alights.

MECHANICS OF INSECT FLIGHT

An exhibit that aroused great interest was the series of models to illustrate how the "elastic" design of different types of insect—in some cases extremely complex—influences their wing movements. It was shown by Dr. T. Weis-Fogh, of the Department of Zoology, University of Cambridge.

In the flapping flight of insects, the wing mass must be accelerated, decelerated and stopped at its extreme positions twice during each cycle. This oscillation may become extremely energy-consuming when the frequency is high. However, the expense can be much reduced by means of springs which absorb the kinetic energy of the wings when they are decelerated and release it again when the wings start to move in the opposite direction. The hardened cuticle of insects was found to be well suited for such spring mechanisms since the material is strong, elastic and having little damping effect.

In a model representing a primitive insect such as a locust, the wings are suspended between an elastic "lid" and two elastic sidewalls, so that a vertical spring system (the "lid") and two horizontal systems (the walls) co-operate to produce an elastic turning moment of the wings about their main hinge. This moment or torque was found to be of the same magnitude as that caused by the wing mass, but the two were of opposite sign during most parts of the stroke. The spring system therefore, cancels the effect of wing inertia.

In more advanced insect types, the same principles seem to apply; the major differences can be explained by the ratio between the vertical and the lateral spring actions. Small quantitative alterations thus produce two extremes, the stable "dragonfly" with the resting wings in a horizontal position and the unstable "blowfly" with the resting wings either in the upper or in the lower position. In the "blowfly," considerable force is necessary to bring the wing into an intermediate position and at a certain angle it suddenly "clicks" to the other extreme. This "clicking" is thought of as the quick release mechanism, now known to be necessary for the high frequency of contraction in flight muscles of higher insects.

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NEW SILVER RIVET CONTACTS

A Composite Design Brings Economy

Messrs. Johnson, Matthey and Company, Limited, 73 Hatton-garden, London, E.C.1, have now announced that they have developed composite contacts, comprising a silver facing on a copper backing and that these can be produced at a lower cost, size for size, than the larger types of solid silver rivets. The copper shank, which is tubular in section to simplify riveting, is efficient both electrically and thermally, while the thickness of the silver face—which is standardised at a minimum of one-third of the total head thickness—ensures that the contact life is not shortened by the composite construction. The rivets are given a light silver deposit on the underside of the head to provide good electrical contact with the backing.

The new contacts are of two main types with either flat or domed contact faces. In each of these types four head sizes from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter are available, while there are three nominal shank lengths of 0·03 in., 0·06 in. and 0·09 in.

CONSOLIDATION OF BALLAST

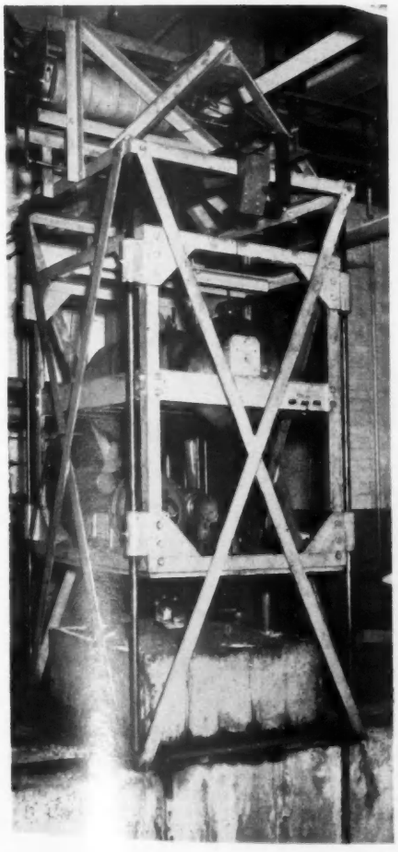
EXPERIENCE WITH MECHANICAL METHODS

Even after more than 100 years of railways in their present form there still exist diverse and controversial opinions on the functions and make-up of ballasted railway permanent way. Only in recent years have investigations started to determine such fundamentals as the optimum depth, shoulder width and size of ballast stone. In the absence of definite standards the methods available for the consolidation of ballast are varied and not always satisfactory. The methods of ballast consolidation, past and present, and the results of tests on ballast tamping machines made on the London Midland Region, were the subject of a paper* and discussion at the Institution of Civil Engineers.

The demands made on permanent way by high speeds and heavy axle loads, and the increasing shortage of manpower on the railways had, it was noted, focussed the attention on the need for quicker and more efficient ways of consolidating ballast. Ballast consolidation, the most costly item in day-to-day maintenance of the track, might even be considered as the most important item since many of the defects of the track and ill effects on the rolling stock sprang from imperfect horizontal and vertical alignment. Good consolidation was essential to good alignment.

Before the first World War ballast was compacted under the sleepers with a beater pick, a tool like a blunt-ended pickaxe. Then came a more precise method—"measured shovel packing." By this method not only was the vertical alignment of the unloaded track determined by means of specially graduated siting boards, but also the voids underneath the sleepers, which became apparent only when traffic passed. The voids were measured with a small deflection meter called a void meter. This instrument sat on the ballast and recorded the vertical movement of the underside of the rail. Special calibrations on both the siting boards and the void meters determined the quantity of limestone chippings necessary under the sleeper to eliminate the low spot. Outputs of 60 sleepers packed per day were attainable with a gang of five men, but the method required intelligent and careful work for it to be fully effective.

* "Consolidation of Ballast," by Idris George White, A.M.I.C.E., Assist. (Per. Way Maintenance) to Chief Civil Engineer, L.M.R.; Railway Paper No. 60, Institution of Civil Engineers, submitted for discussion Tuesday, January 10, 1956.



ON-TRACK MACHINES

Mechanical consolidation methods were the natural outcome, and those machines developed by the Swiss, French and American railways fell into two main categories: (1) "on-track" and (2) "off-track" machines, and both categories could be sub-divided into two types: (*a*) vibratory and (*b*) percussion machines.

On-track machines were self-propelled, both the power and consolidation units being mounted on wheels. Off-track machines had a power unit which stood clear of the track while the consolidation units were operated on the track.

On-track machines had many advantages over off-track systems. The former were more rapid, gave more uniform consolidation, required less manpower and were less fatiguing on the operators than the latter. Against this had to be set the necessity for full possession of the track (complete freedom from all trains over a certain period) the considerable capital outlay for the larger on-track machines and the limitation of their use to plain track (as opposed to points and crossings).

Both categories of consolidating machines (or tampers) worked on the same principle. Vibrating or percussion blades were driven into the ballast under the sleeper and the consolidation was produced by the repositioning of the ballast stone under the vibration or repeated hammer blows. The main drawback to the percussion type of tamper was its tendency to pulverise the ballast. The stones lost their angularity (an important quality) and the dust clogged the lower ballast to the detriment of the track drainage.

On-track machines of the percussion type included the Swiss Matisa tamper. This was a large machine mounted on wheels with the compacting unit between the axles. The tamping blades were plunged into the ballast on either side of the sleeper and then gradually forced towards each other until they reached the sides of the sleeper. Several passes were made for each sleeper, leaving a well compacted rectangular bed. The latest Matisa tamper could compact to a depth of 9 in. below the underside of the sleeper; outputs of 200 sleepers per hour were obtained with this tamper.

The American Jackson tamper was a vibratory on-track machine. Like the Matisa, it was a large wheel-mounted unit controlled by a single operator. Curved vibrating blades were plunged 10 or 12 times into the ballast underneath the sleeper until the individual stones settled together to produce a closely keyed and compacted region. The Jackson tamper had an output of 120 sleepers packed per hour.

Recently, small-scale tests on off-track tampers had been made by the London Midland Region of British Railways. Of the percussion type, hand operated Bosch, Kango and Broomwade tampers were tested. These worked on a similar principle to the concrete breaker, and were powered by generators and air compressor respectively which stood in the cess. Outputs of from 20 to 50 sleepers per hour were reached.

For comparison, vibratory off-track tampers called Vibromax, Wacker and Jackson were tested as well. Powered by mobile petrol generators standing in the cess, these machines consolidated the ballast at a rate of 60-70 sleepers per hour.

In conclusion, it was suggested that a comparison of the outputs and operation characteristics showed that these two categories of tampers were complementary to each other. The on-track tampers with their high output and low manpower requirements should be used on long runs of unrestricted track in possession times. Off-track tampers would serve in difficult localities such as points and crossings, bridges and station grounds, and where the possession was too limited to allow the economical use of the faster machines. Finally, if considerable lengths of track were to be maintained by machine to the high standard required by present day operating departments, then some solution had to be found which allowed sufficient possession time for the economical use of the on-track machines.

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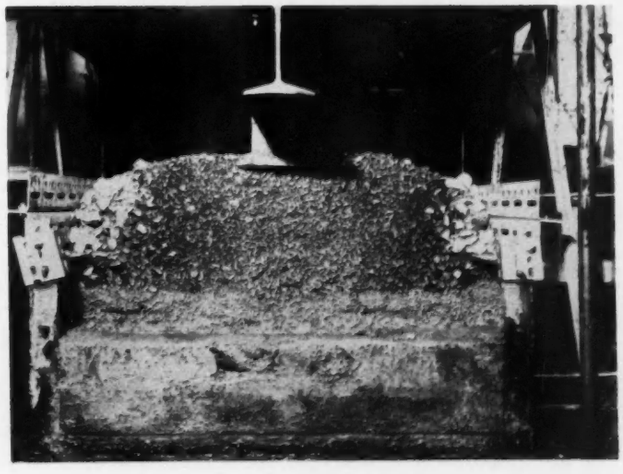
TRACK LIFE STUDIED IN LABORATORY

Train Simulator Built

In connection with the study of remedial measures for deteriorated track formation, a machine has been designed and constructed in the Soil Mechanics Section of British Railways, Western Region, to simulate the action of a train passing over a sleeper. It consists of three main parts: (1) a cage, free to move in a vertical direction, with a platform at the bottom carrying a bearing pedestal; (2) a test box, 2 ft. 6 in. by 2 ft. 6 in. by 1 ft. 0 in. (with an arrangement for increasing the height by 6 in.) in which samples of track formation are placed; and (3) a concrete foundation supporting a rigid framework with rods at the corners to guide the vertical movement of the cage. The cage transmits the load to the



The continuous action of passing trains on the ballast and sub-grade is being investigated in Western Region's soil mechanics laboratory, using this train simulator. One hour's running of the simulator represents five days' train operation, assuming 4,000 axle loads per day.

sample in the test box through the bearing pedestal which remains in contact with the sample throughout the test; its rate of movement is varied by means of eccentric flywheels rotating in opposite directions, and driven by a 2 h.p. motor bolted to the platform.

In order to assess the value of a blanket of stonedust for preventing slurrying, tests were carried out with both Old Red Sandstone and Keuper Marl as formations, with and without a layer of stonedust between the formation and chippings. It was demonstrated that a 6 in. layer of stonedust was effective in preventing slurrying. For these tests the impact load varied between zero and 3,000 lb., equivalent to 5·3 tons per square foot; the rate of application was 340 blows per minute and the area of the bearing pedestal 35 square inch. One hour's running of the impulse loader represents 5 days' running of trains, assuming 4,000 axle loads per day.

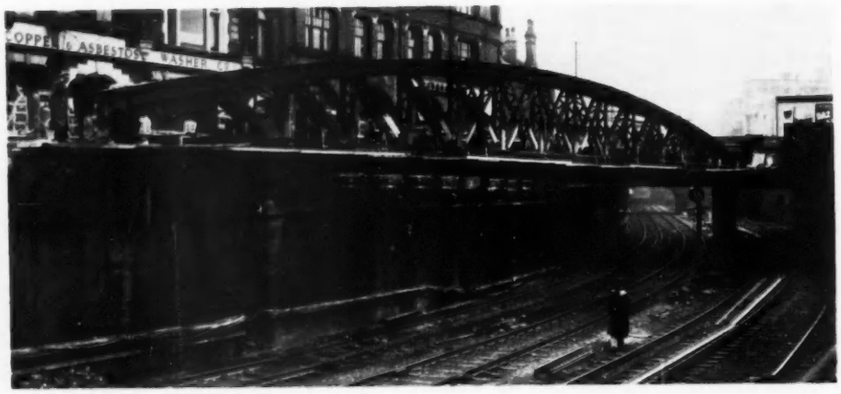


Fig. 1 Livery-street road bridge, Birmingham, over the Western Region tracks, British Railways. The bottom chord of the single truss was so heavily corroded as to require strengthening and the decking had to be replaced. The tension in the chord was reduced by a prestressing load of 230 tons applied through eight Macalloy bars of 1 in. diameter.

PRESTRESSING A STEEL GIRDER

RENEWAL OF A CORRODED RAILWAY BRIDGE

Outside Snow Hill Station, Birmingham, the Western Region main line to the north runs adjacent to, and parallel with, the busy thoroughfare of Livery Street until, half a mile beyond the station, the line skews under the road at an acute angle. At this point, and as shown in Fig. 1, above, Livery Street bridge spans the Up and Down relief lines, the roadway being carried on cross girders resting on the top of a retaining wall on one side and underslung from a hog-back truss girder on the other. This truss girder, 115 ft. long, spans from the retaining wall to a steel trestle between the Up relief and Down main lines, and the cross girders cantilever beyond it to carry a footpath 7 ft. 6 in. wide. The bridge, of steel construction, was built in 1906.

The site is a particularly smoky one and the underside of the cross girders and, in particular, the bottom chord of the truss girder suffered severe corrosion. This weakening of the girder-work, coupled with the difficulty experienced in keeping a good surface to the road because of movement between the thin layer of road metalling (less than 5 inches in places) and the flat steel-plate decking, which was actually polished bright by the rubbing of the macadam, resulted in a decision to reconstruct the whole of the decking and to strengthen the truss girder. Though the road traffic could be diverted without serious inconvenience to use, the strengthening of the truss girder spanning busy rail tracks, where clearances were insufficient to permit the erection of any temporary supports so that the dead load stresses could be removed, presented a difficult problem. Detailed examination showed the top chord and the web members, for the most part, to have been unaffected by the corrosion and to be in good condition. So it was decided to strengthen the truss by prestressing the bottom chord after restoring the sectional area by the addition of steel flats welded to the vertical legs of the chord angles where corrosion had been the most severe, and to reduce the unsupported length of the compression chord by the addition of portal frames spanning the footpath and connected to the extremities of three pairs of the cross girders.

RECONSTRUCTION ORDER

The reconstruction was undertaken in the early part of 1955. With the road closed to traffic, the decking was stripped, and while the old cross girders, underslung from the panel points of the truss and spaced at 8 ft. 4 in. centres, were still in position, and after the web members and the tension chord had been repaired, the tension in the bottom chord was reduced by a prestressing force of 230 tons applied through eight Macalloy steel bars of 1 in. diameter, four on each side, as shown in Fig. 2. As may also be seen in this illustration, the rods were anchored to massive welded mild-steel brackets secured by high-strength bolts to the chord plates and flanges at points 3 ft. from each end of the girder. Two Lee-McCall jacks were used to stress the bars, one bar on each side of the chord being stressed simultaneously, and this work in progress is illustrated in Fig. 3. The load applied to the first pair was greater than that applied to the next pair which in turn were stressed more highly than the next and so on, so that ultimately the load was the same on all eight bars. Prior to stressing and throughout the operation the bars were temporarily supported at intervals of 14 ft. throughout their length. As a result of the prestressing, the chord shortened half an inch, the sliding bearing moving by that amount across the bedplate on the retaining wall; the camber of the girder increased by $\frac{3}{4}$ in. at the centre of the span. Changes of strain in the girder members were measured with electric resistance strain gauges and were found to agree closely with those expected. Subsequently, the prestressing bars were wrapped in canvas and protected with bitumen before being encased in a concrete filling which covered the whole chord.

The new cross girders, hog-backed and all-welded, were placed in position by cranes

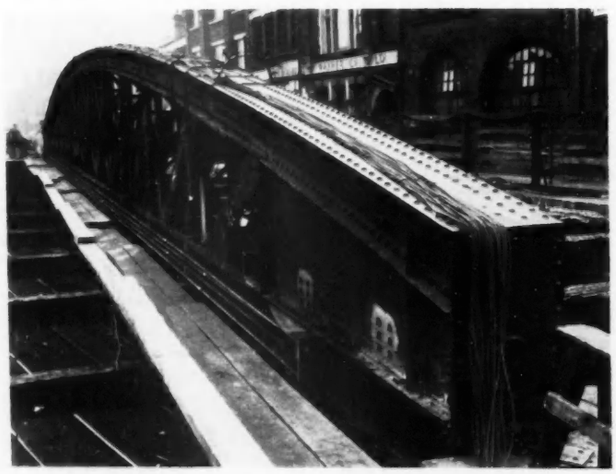


Fig. 2 The main truss showing, on the left, the cantilevered beams below the footpath and, on the right, the girder below the roadway. Four of the prestressing rods are shown prior to being loaded.

Fig. 3 Eight prestressing rods were used in two frames of four. The load was applied simultaneously and equally to one rod on each side of the chord. The residual loads in the rods were designed to be equal.

operating from the railway tracks below. Spaced at 4 ft. 2 in. centres, they are pin-connected to new steel lugs passing through and bolted to the chord panel points intermediate between the panel points of the truss; this arrangement allowed the steelwork to be fitted clear of web gussets and prior to the removal of the old cross girders. The portal bracings giving lateral support to the top chord have been connected to the ends of three pairs of the cross girders near the middle of the span. The roadway, finished with a 3 in. thick layer of rolled asphalt on concrete, is carried on pre-cast reinforced-concrete jack-arches bedded on concrete skewbacks pre-cast on the bottom flanges of the cross-girders at the makers' works. The footpath consists of a layer of asphalt on pre-cast prestressed concrete planks, 12 in. by 3 in. thick, spanning between a continuous shelf angle on the steel plate parapet and a channel stringer adjacent to the truss girder. All exposed steelwork under the bridge has been protected with a coating of Ruberoid Plastic Compound No. 201 applied directly to the steel.

The bridge as originally built was designed to carry a 32 ton boiler trolley drawn by a 15 ton traction engine. The new decking and the strengthened truss girder have increased the capacity to 15 B.S. loading units, with a maximum axle load of 22 tons.

The scheme was worked out and detailed in the Steelwork Office under the direction of Mr. M. G. R. Smith, M.B.E., the Chief Civil Engineer, Western Region, at Paddington, and to the approval of Sir Herbert Manzoni, C.B.E., City Engineer, Birmingham. The new steelwork, 47 tons, was fabricated and supplied by Jesse Tildesley, Limited, Willerhall, Staffs., at whose works the concrete skewbacks were cast on the cross girders by A. F. R. Godfrey and Company, Limited. The pre-cast reinforced-concrete jack arches were made in the Western Region concrete depot at Taunton, and the pretensioned prestressed concrete planks for the footpath were supplied by the Bristol Stone and Concrete Company, Limited, Holcombe, near Bath. The site work was carried out by railway labour under the direction of Mr. J. R. Hammond, District Engineer at Wolverhampton. The strain measurements taken during the prestressing of the truss girder were recorded by the staff of the Research Department of the British Transport Commission under the direction of Mr. T. Baldwin, Superintendent of the Engineering Division at Derby.

ATOMIC REVIEW

Power from hydrogen fusion—Plutonium extraction—United Kingdom Atomic Energy Authority publishes abstracts of declassified papers on materials and techniques—Anxious citizens cold shoulder atomic installations.

Thermonuclear Reactions

The problem of controlling the hydrogen fusion reaction to give a new source of electric power has received considerable attention in recent weeks and it might therefore be useful to show how this process fits in with other nuclear reactions. The extent to which the energy evolved is likely to exceed that produced in fission reactions can also be indicated.

The masses of most nuclear particles have been estimated with considerable accuracy, but it is found that atomic nuclei have masses smaller than the total mass of their constituent particles or nucleons; in accordance with Einstein's principle of mass-energy equivalence (one unit of atomic weight corresponds to 936 MeV) this "mass defect" represents the "binding energy" of the nucleus. Thus, when a nucleus is formed from its constituents some energy is released, and as in chemical reactions this energy is a measure of the stability of the given nucleus. The accompanying graph shows the binding energy per nucleon plotted against mass number, and the points represent particular elements or isotopes. Thus, the isotopes helium 4, carbon 12 and oxygen 16, which appear well above the curve, are very stable.

Now if the curve is examined it will be seen that the point marked U is in the region of the heavy fissile isotopes uranium 235, uranium 233 and plutonium 239, while the point H indicates the neighbourhood of hydrogen and its isotopes deuterium (H^2) and tritium (H^3). On fission, uranium breaks down into isotopes in the medium mass number range, and hydrogen fusion produces helium. It will be seen that change of energy on fusion (the steep left-hand part of the curve) is considerably greater than that due to fission (the almost horizontal right-hand section), and consequently the output of energy in the first case is much greater, as the comparative powers of the hydrogen and uranium bombs indicate. This characteristic together with the abundance in nature of hydrogen, the comparative simplicity of dealing with reaction products, and the simplification of radioactivity shielding problems, makes the fusion process extremely attractive. On the other hand, in order to initiate the fusion reaction extremely high temperatures are necessary (of the order of a million degrees Centigrade), in the same way that heat energy must be supplied to coal before it will ignite, and this makes containment very difficult. At present, research into fusion reactions seems to be taking three directions: high pulsed currents in gas discharges (ENGINEERING, page 322, May 11, 1956); shock waves from small explosions; and the use of high-powered particle accelerators. Work on the first method is known to have been carried out in Russia and the United Kingdom and on the second in America.

Materials

Private firms in the United States can now possess and use "special nuclear material" (plutonium, uranium 233 and uranium enriched in the isotopes 233 or 235) under licence from the Atomic Energy Commission. Companies are at liberty to use these fuels in privately owned research and power reactors and for other purposes. Private American companies are also to be allowed to build and operate plants for processing irradiated fuel elements from research and power reactors, and the A.E.C. is prepared to put knowledge at the disposal of approved firms for this purpose.

EXTRACTING PLUTONIUM

The process of extracting plutonium from irradiated natural uranium fuel elements taken from the Windscale piles has recently been described by Sir Christopher Hinton in the Castner Lecture to the Society of Chemical Industry. The separation plant performs two functions: it extracts plutonium and reclaims unused uranium. Solvent extraction has been found to be the most convenient method of separation, and the solvent chosen is dibutyl carbitol. Plutonium is present in the fuel slugs on withdrawal from the reactor to the extent of about 300 parts per million and the separation plant is designed to give 99·9 per cent. recovery. The input to the plant is in the region of several hundred tons a year of uranium, mixed fission products and plutonium, while the yield of plutonium amounts to some hundreds of kilograms a year. The plutonium used for the Monte Bello trials was produced in little more than six months, from the end of 1951 to the middle of 1952.

The United Kingdom Atomic Energy Authority have recently published a number of abstracts describing work which is now unclassified. In the present article this work will be recognisable as such since in each case the note will be followed by the Authority's reference classification.

The determination of thorium in plant intermediate products after a sulphuric acid leach of monazite rock may be carried out in the following way. Thorium is separated from any sulphate and chloride ions by precipitation as the hydroxide. The solution is centrifuged, supernatant liquor is decanted off and the precipitate dissolved with nitric acid. The thorium is extracted from other impurities into a solution of 40 per cent. T.B.P./xylene, and back extracted into water. It is then estimated by titration with a solution of ethylene diamine tetra-acetic acid. The method as described is suitable for solutions containing between 30 and 500 mgm. thorium and up to 350 mgm. of rare earth phosphates in the aliquot taken. (Chemical Services Department, Springfield Works. IGO-AM/S.10.)

FUMELESS DISSOLVING OF URANIUM

Laboratory experiments have been performed in which uranium was dissolved in nitric acid in the presence of oxygen. The overall reaction

$$2U + 3O_2 + 4HNO_3 \rightarrow 2UO_2(NO_3)_2 + 2H_2O$$

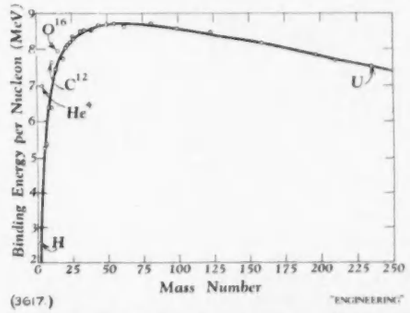
can be made to occur without emission of fumes. (G. L. Miles. AERE C/R 1804.)

Investigators have studied the composition of sodium uranate produced by the reaction of fused sodium hydroxide and uranium trioxide. A bulky red compound of composition Na_4UO_5 is first formed but on heating above 400 deg. C. it rapidly changes to a dense stable yellow compound in which the uranium to sodium ratio is in the region of 1 : 0·5 to 1 : 1·0. In determining the composition of the latter compound considerable analytical difficulties were experienced and it is not known whether the scatter of results is due to variability of composition inherent in the process of preparation or to inaccuracies in analysis. (J. R. Findlay, J. N. Gregory and G. Weldrick. AERE C/M 265.)

The isotopes manganese 54, cobalt 56, cobalt 58, zinc 65 and niobium 95 m. have been separated in a carrier-free state by the use of anion exchange resin. These separations were all carried out using De-Acidite FF anion exchange resin in strongly acid solution. Under these conditions the metals concerned form anionic complexes of varying stability and absorbability, and the separations are effected by choosing acid strengths appropriate to adsorption or elution. The work was founded on two papers by K. A. Kraus and G. E. Moore (*J.A.C.S.*, vol. 73, page 9, 1951, and vol. 75, page 1460, 1953) which describe the behaviour of macroscopic amounts of transition metals on anion resin columns in HCl solutions of different strengths, and the behaviour of Zr and Nb in HCl/HF mixtures. (C. E. Mellish. AERE I/M 39.)

TAILPIECE

The selection of sites for nuclear power stations and atomic research establishments is a problem much complicated by local fears and opposition. The Central Electricity Authority hope to begin building one of their first two commercial atomic power stations at Bradwell in Essex next year and erection of a second station at Berkeley in Gloucestershire on the Severn Estuary is due to begin in about a year's time. It is expected that the Berkeley station will come into operation in 1960-61, and a further station on an adjacent site should by that time be already under construction. Mr. A. C. Thirtle, controller of the South Western Division of the C.E.A., has said that the south bank of the Severn Estuary from south-west of Gloucester to Bridgwater Bay fulfills most of the special requirements for nuclear power sites, and that stations in addition to the one at Berkeley are likely to be built in the West Country. In addition, the South of Scotland Electricity Board expect in a few months to invite the four main industrial atomic energy groups to tender for a nuclear power station, which will probably be sited in the vicinity of Portincross, near Ardrossan on the Firth of Clyde. Northern Ireland too is hoping to have an atomic power station, which may



(3617.) "ENGINEERING"

Binding energy per nucleon in an atomic nucleus plotted against mass number. The curve shows how much the energy released on hydrogen fusion is likely to exceed that evolved during uranium fission.

be situated near Belfast. Though so far little has been heard from the inhabitants of Berkeley or Portincross, the people of Bradwell have waxed indignant, basing their case mainly on the harm that warm or radioactive effluents might bring about when discharged into the sea. Oyster fishing, it was thought, would suffer, and the teredo worm and the gribble, pests which apparently thrive in warm water, would cause serious depredations to woodwork. There have also been objections to the possible choice of Winfrith Heath, Dorset, by the United Kingdom Atomic Energy Authority as a site for a station to carry out similar work to that performed at Harwell. Though most of the dangers are much exaggerated, hazards of contamination and injury do in fact exist, as Professor Jacques Parisot, the new President of the World Health Organisation, and members of the International Law Commission have recently pointed out. But it must always be borne in mind that these difficulties can be and have already been overcome—the insurance companies, for example, have great confidence in the longevity of Atomic Energy Authority employees—and in any case the establishment of nuclear power stations is a national necessity.

It would be tragic if each projected station were to be treated as a purely local issue so that consequent delays hazarded the well-being of the entire community. Due consideration must of course be given to local anxieties but these could in most cases be dispelled by sound public relations. The importance of issuing accurate and comprehensive information, wherever possible, cannot be over-emphasised.

This Russian " wind motor " designed for farm use has speed-stabilising blades so that the wheel is effectively governed to 60 r.p.m.; it is rated at 14 h.p. in an 18 m.p.h. wind.

FIXED-SPEED WIND MOTOR

Variable Pitch Blade Tips

Among the exhibits at the recent Leipzig Fair was the " wind motor " of Russian origin shown in the accompanying illustration. As can be seen, the wind wheel consists of three blades; the main part of each blade is of fixed pitch but the tip section is free to incline under the action of the wind, so that the wheel has blades which are of partly variable pitch. The pitch of the blade tips is controlled solely by the speed of the wind and has the effect of governing the wheel speed to 60 r.p.m. Even with the highest speeds of wind the wheel is claimed to revolve at no more than 5 per cent. greater speed than the nominal 60 r.p.m. No information is available as to the material used for the blades, though cast iron has been used for the headpiece supporting the wheel. The wheel is kept presented into the wind by the tail vanes to be seen in the illustration.

The wind motor has been designed for generating electrical power for farms in isolated areas, or for directly driving pumps or other mechanical equipment. The advantage of a fixed speed of rotation whether the motor is being used to drive a generator or mechanical equipment is, of course, that it is possible to design the driven plant for optimum efficiency. As exhibited, the rotation of the wheel was transmitted to ground level through bevel gears and shafting, though it would be simple enough to make other arrangements.

The wind motor at Leipzig was mounted on a tower consisting of a simple bolted frame of angle sections which raised the wheel axis to 16 metres (50 ft.) above ground level. The overall diameter of the wheel is given as 12 m. (39 ft.) and the motor is claimed to operate effectively at wind speeds from 9 m.p.h. up to 90 m.p.h., though it would appear that the optimum wind speed is 18 m.p.h. At this optimum speed the output available at the foot of the tower is rated as 14 h.p. and the rotational speed has been increased six-fold to 360 r.p.m.; the transmission efficiency is said to be about 85 per cent. after passing through a gear box at wheel level giving a speed increase of 1 to 3 and a second box at the base of the tower with a 1 to 2 ratio. A wind speed of at least 8 m.p.h. is required to start the wheel rotating from rest.

Few other data are available here about this machine, except that it appears to be obtainable through " Machinoexport," Moscow.

PRODUCING STEEL REINFORCEMENT FABRIC

A Modified Standard Machine for Unskilled Labour

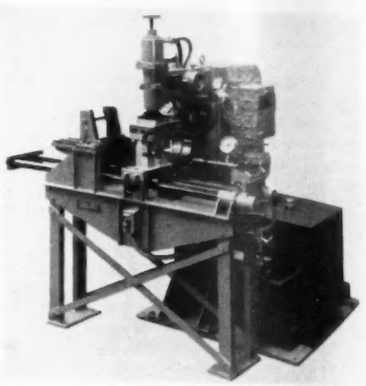
An example of how a relatively simple modification of a standard machine can enable production rates comparable with those of a specially-built machine to be achieved is provided by the spot-welder illustrated herewith. Hitherto, brick force reinforcement fabric, which usually consists of two 10 s.w.g. steel main wires, with 12 s.w.g. cross-wires, has been produced by fusion or single-head spot-welders. Sciaky Electric Welding Machines, Limited, Farnham-road, Slough, Buckinghamshire, have designed a modification of their standard high-speed air-operated 30 kVa welder to produce the fabric at a rate of 30 welding strokes (that is, 60 welded joints) per minute. Only an unskilled operator is required. The machine will accommodate main wires spaced at 2, 3½ or 6 in. centres. The cross-wires are usually at 12 in. centres, but this distance is also adjustable.

HYDRAULIC INDEXING

The additions to the basic machine comprise; a mechanism for indexing the fabric at the correct cross-wire pitch, a magazine for feeding the cross-wires, and water-cooled electrode dies which produce two welds simultaneously. Indexing is by a double-acting hydraulic cylinder, fed by a self-contained pump and tank mounted on a base plate integral with the machine. Twin pawls engage a previously-welded cross-wire and draw the fabric through the machine the required distance; they then return to perform the next stroke. The stroke of the indexing mechanism is adjustable, to vary the spacing of the cross-wires as required. Welded fabric leaves the machine on the right-hand side, and can be wound on to spools or cut to short lengths as required.

AUTOMATIC OPERATION

To set the machine up it is necessary to feed the main wires by hand through guides until they reach the electrode position, and to load the cross-wire magazine with previously-cut and straightened lengths of wire. The first set of joints is then welded under hand control until a cross-wire reaches the indexing pawls, when the machine takes over and continues to attach cross-wires automatically. The welding sequence, is automatic.



The addition of a magazine and a feed mechanism to this Sciaky welding machine enables unskilled labour to produce reinforcement fabric at speed.

The machine as illustrated is designed for the production of a specific type of reinforcement fabric, but the basic machine is easily adaptable for the automatic welding of other wire goods, provided that the mesh dimensions are constant and that the cross-wires are not less than 14 s.w.g.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

GLASGOW
Annual General Meeting. Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., May 30, 7.30 p.m.

LIVERPOOL
Annual General Meeting. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., June 1, 6.30 p.m.

OXFORD
Annual General Meeting. Oxford, Reading and District Branch. Y.M.C.A., 10 George-street, Oxford. Sat., June 2, 7 p.m.

Building Centre

LONDON
Films Illustrating Building Plant and Machinery. Wed., May 30, 12.45 p.m.

Chemical Society

LONDON
Centenary Lecture on " The Present Status of the Trans-uranium Elements," by Professor G. T. Seaborg. Thurs., June 7, 7.30 p.m.

LIVERPOOL
Centenary Lecture on " The Present Status of the Trans-uranium Elements," by Professor G. T. Seaborg. Chemistry Lecture Theatre, The University, Liverpool. Tues., June 5, 5.30 p.m.

Incorporated Plant Engineers

SHEFFIELD
Various short papers by branch members. Sheffield Branch. Grand Hotel, Sheffield. Thurs., May 31, 7.30 p.m.

Institute of Metals

LONDON
" Some Recent Studies of Irradiation Effects in Metals and Other Solids," by Professor R. Smoluchowski. Institution of Naval Architects, 10 Upper Belgrave-street, S.W.1. Wed., June 13, 6.30 p.m.

Institution of Civil Engineers

LONDON
" Kwinana Jetty," by Peter Murray and D. N. Collett. Works Construction Division. Tues., May 29, 5.30 p.m.*
Annual General Meeting (Corporate Members only). Tues., June 5, 5.30 p.m.*

Institution of Mechanical Engineers

BIRMINGHAM
Annual General Meeting and Chairman's Address. Midland Graduates' Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., May 28, 6 p.m.

Institution of Naval Architects

LONDON
" The Planing Performance, Pressures and Stresses in a High-Speed Launch," by Commander P. Du Cane, R.N. Thurs., June 7, 4.45 p.m.*

Institution of Production Engineers

PETERBOROUGH
One-day conference on "Aspects of Automation." North Midlands Regional Meeting. At works of F. Perkins, Ltd., Peterborough. Sat., June 2, 10 a.m.

Royal Society

LONDON
Croonian Lecture on " Some Experiments About Thinking," by Sir Frederick Bartlett. Thurs., May 31, 4.30 p.m.*

Royal Society of Arts

LONDON
" The Influence of National Character on Design," by Paul Reilly. Wed., June 6, 2.30 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. " Process Analytical Instrumentation," by A. G. Stanley and J. F. Brown. Manson House, 26 Portland-place, W.1. Tues., May 29, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceeding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 74..)
Institution of Naval Architects, 10 [illegible] Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, [illegible] Chesterfield-street, London, W.1. (GROsvenor 5254.)
Royal Society, Burlington House, Pic[illegible]y, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-st[illegible] Adelphi, London, W.C.2. (TRAfalgar 2366.)
Society of Instrument Technology, [illegible]ueen Anne-street, London, W.1. (LANgham 4251.)

SAND-PUMP DREDGER FOR INDONESIA

ACCEPTANCE TRIALS COMPLETED IN GERMANY

A Diesel-electric sand-pump dredger, possessing various features of technical interest, has been completed recently to the order of the Government of Indonesia by Orenstein-Koppel und Lübecker Maschinenbau A.G., of Lübeck, Germany, by whose courtesy we were enabled to attend the acceptance trials of the vessel at Travemünde on May 9. The Sumatra II, as she is named, is the largest dredger of this type to be built in Germany since 1945, and the ninth unit of the Indonesian dredging fleet to be constructed by the firm since 1950. The profile of the vessel is shown below.

The Sumatra II has a length overall of 107 m. (351 ft.) and between perpendiculars of 101 m. (331 ft.); a breadth moulded of 19 m. (62 ft.); and a depth to the upper deck of 8 m. (26 ft.). The draught loaded is 5·93 m. (19 ft.), and the registered tonnage 4,698 gross and 2,012 net. She has been built to the classification of the Bureau Veritas. The hopper capacity is 3,000 cub. m. (3,924 cub. yards), which corresponds to a load of 4,250 tons of spoil, and can be filled in less than 40 minutes when dredging the sand or mud on which the vessel is intended to operate. There are 12 hopper compartments, six on each side of the central well for the drag-head suction pipe, which is hinged at its forward end and drawn along the bottom like a trawl by the forward motion of the ship. Dredging can be carried on at any depth between 8 m. (26 ft.) and 15 m. (49 ft.) below water level. The depth at which the suction head is operating is shown on deck by an indicator mounted on the port side of the structure supporting the 120 h.p. hoisting motor, and the ground depth is continually surveyed by an echo-sounder, indicating in the control room on the bridge from which the dredging master controls the whole of the process of dredging.

DIESEL-ELECTRIC DRIVES

The whole operation of the vessel is electric, the power being supplied, for both propulsion and dredging, by three single-acting four-stroke seven-cylinder M.A.N. Diesel engines, supercharged to give 1,350 b.h..p each at 275 r.p.m. and directly coupled to 850 kW generators delivering direct current at 600 volts. The twin four-bladed propellers are driven at 130 r.p.m., corresponding to a speed of 10½ knots, by direct-current motors running at 1,000 r.p.m. and connected to the propeller shafts through reduction gears. The dredging pump, which has an impeller diameter of 1,350 mm. (4 ft. 5 in.), is driven by an electric motor of 2,500 h.p.

The diameter of the draghead suction pipe is 1,100 mm. (3 ft. 3½ in.). The pump discharges through two fore-and-aft pipes of 700 mm. (2 ft. 3½ in.) bore, in which are the hydraulically-operated sluice valves regulating the flow to the 12 hopper compartments. As the spoil settles in the compartments, the water in the mixture rises to the top and overflows through drain funnels into ducts leading into the centre well; thus as there is no overside discharge of muddy water it has been practicable to use light colours in painting the hull. Outwardly there is little in the vessel's appearance to suggest her functions.

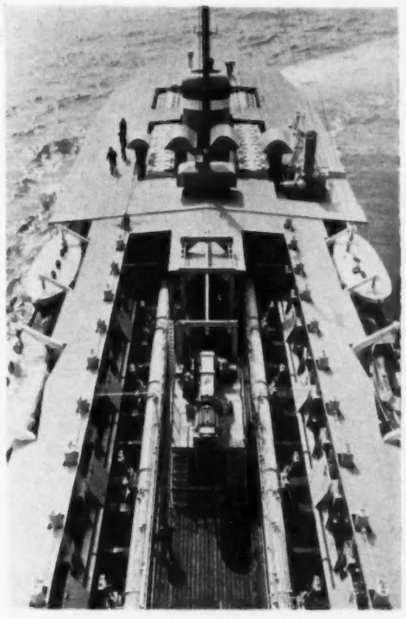
As will be seen, the propelling machinery of the Sumatra II is arranged aft. In addition to the main engines driving the 850 kW generators, there are three Diesel-driven generating sets of 200 kW each, running at 275 r.p.m., to supply the various cranes, hoists, small pumps and other auxiliaries, as well as an auxiliary generator of 400 kW capacity, running at 700 r.p.m., and a harbour generator with an output of 100 kW at 1,300 r.p.m. The emergency set, of 15 kW output, runs at 1,250 r.p.m. The steering gear is electro-hydraulic, operating twin balanced rudders to give the necessary close control at slow speeds while dredging.

Deck machinery, all of which is electric, includes two boat winches of 5 h.p., a windlass driven by a 31 h.p. motor, and two warping capstans, each of 20 h.p. There are also two luffing cranes, one on the raised forecastle and the other abreast of the mainmast, each capable of lifting 2 tons at a radius of 10 m. (32 ft. 9 in.)

SPOIL HANDLING

The engine room containing the dredging pump is forward, directly under the bridge superstructure, on the after side of which, to starboard, is the control room for the dredging master. In this room are also the controls for the bottom doors for emptying the hoppers. There are two doors to each of the 12 hoppers and they are opened and closed hydraulically, under electric control, either singly or simultaneously. On the occasion of the acceptance trial, the contents of all 12 hoppers were dumped simultaneously, causing the vessel to rise in the water a matter of 8 ft. as she was suddenly lightened. A hopper flushing pump with a capacity of 700 cub. m. per hour is provided for washing down the hoppers. A pump discharge pipe is also built into the suction draghead, to clear the cutting teeth of mud or clinging debris. The view looking into the well of the vessel is shown in the illustration at the top of the page.

The vessel is very completely equipped with navigating appliances, radar, etc., and with the various amenities desirable for continuous operation in a hot climate. The accommodation for officers and crew is spacious, most of the principal rooms being air-conditioned, and permanent awnings cover most of the open decks, except the space between the hoppers.



The 12 hopper compartments with a combined capacity of 3,000 cub. m. are arranged six on each side of the central well.

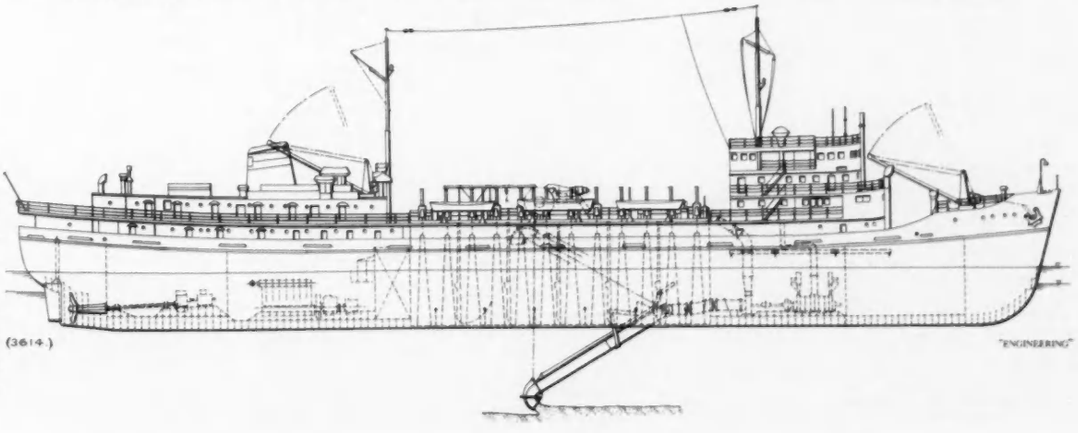
Thus the dredging master has a clear view of the hoppers, sluice valves, hoisting winch, etc., under his control; though, in fact, the valves and winch can be controlled independently from the deck also.

The Sumatra II is to leave Lübeck before the end of May for her permanent base at Djakarta, Indonesia, in charge of the builders' delivery crew, and will then become the "flagship" of the Indonesian Republic's dredging fleet.

★ ★ ★

"RIVERS OF LIFE"

Water supply in this country has become one of the major problems as industrial towns have grown larger. Many reservoirs have been built involving different types of dam construction. Richard Costain Limited, 111 Westminster Bridge-road, London, S.E.1, have produced a colour film showing both diagrammatically and by direct photography how two recent earth-filled dams have been constructed. The examples taken are the Usk Dam, which will supply Cardiff and district, and the Weir Wood Reservoir which is for the Crawley New Town. Shots of both are shown to illustrate succeeding stages of construction and the various troubles encountered are mentioned in the commentary. The film may be borrowed from the company.



"Sumatra II" has an overall length of 351 ft. and a moulded breadth of 62 ft. Dredging can be carried out at any depth between 26 ft. and 49 ft. below water level, and a full load (3614) of 4,250 tons of spoil can be raised in 40 minutes.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *January* 27, *page* 111; *or April* 27, *page* 287. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Packaging Salon, Fifth International; and 34th International Fair.—Tues., May 29, to Wed., June 13, at Padua. *Agents:* Italian Chamber of Commerce for Great Britain and British Commonwealth, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

Vapour-Phase Chromatography.—Wed., May 30, to Fri., June 1, in London. Organised by the Hydrocarbon Research Group of the Institute of Petroleum, 26 Portland-place, London, W.1. (Tel. LANgham 2250.) Apply to the organising secretaries: Mr. D. M. Desty and Mr. H. C. Rampton, the Research Station, British Petroleum Co., Ltd., Sunbury-on-Thames.

Bath and West Agricultural Show.—Wed., May 30, to Sat., June 2, at Cardiff. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

High Tension Networks, 16th International Conference on.—Wed., May 30, to Sat., June 9, at the Fondation Berthelot, 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Réseaux Electriques. Apply to the British Committee, Thorncroft Manor, Leatherhead.

***ASLIB Annual Conference.**—Fri., June 1, to Mon., June 4, at the Hotel Metropole, Brighton. Theme: "Information Service: The Cost, the Value and the Means." Organised by ASLIB (Association of Special Libraries and Information Bureaux), 4 Palace-gate, London, W.8. Tel. WEStern 6321.

***Orebro-Expon Industrial and Commercial Fair.**—Fri., June 1, to Sun., June 10, at Orebro-Expon. Apply to Gosta Ottoson, Orebro-Expon, Orebro, Sweden.

Barcelona Samples Fair, 24th International.—Fri., June 1, to Wed., June 20, at Barcelona. Apply to the Spanish Tourist Service, 4 West Halkin-street, Belgrave-square, London, S.W.1. Tel. SLOane 6124; or to the Economic Department, Spanish Embassy, 12 Cadogan-place, London, S.W.1. Tel. SLOane 6181.

***Electronics Exhibition.**—Sat., June 2, to Thurs., June 7, in the Palais d'Egmont, Brussels. Organised by the Union Professionnelle des Fabricants et Importateurs de Materiel pour l'Industrie Electronique, 85 Boulevard Emile Jacqmain, Brussells.

***Heat Treatment Practice.**—Tues. and Wed., June 5 and 6, at Ashorne Hill, near Leamington Spa. Organised by the Metallurgy (General) Division of the British Iron and Steel Research Association, 11 Park-lane, London, W.1. Tel. GROsvenor 4751.

Atoms, Electrons and Industry Exhibition.—Wed., June 6, to Fri., June 8, at the Royal West of England Academy, Bristol. Organised by the Electronics Section, Scientific Instrument Manufacturers' Association of Great Britain, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251. Admission free, by ticket.

Light Metals Convention, Third International.—Thurs., June 7, to Sat., June 9, at the Montanistische Hochschule, Leoben, Austria. Information obtainable from the organising committee, Institut für Metallkunke, Montanistische Hochschule, Leoben, Steiermark, Austria.

***Bordeaux International Fair.**—Sun., June 10, to Mon., June 25, at Bordeaux. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Molecular Structure and Spectroscopy, Annual Symposium.—Mon. June 11, to Fri., June 15, at Columbus, Ohio, U.S.A. Apply to the secretariat, Department of Physics, Ohio State University, Columbus, Ohio, U.S.A.

Spectroscopy, Fourth Meeting of Joint Commission on.—Mon., June 11, to Fri., June 15, at Columbus, Ohio, U.S.A. Organised by the International Council of Scientific Unions. Apply to the secretary, Joint Commission on Spectroscopy, Zeeman Laboratorium, Plantage Muidergracht 4, Amsterdam 4, Holland.

***Institute of British Foundrymen, Annual Conference.**—Tues., June 12, to Fri., June 15, at the South Wales Institute of Engineers, Park-place, Cardiff. Organised by the Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester. Tel. Blackfriars 6178.

World Power Conference, Fifth Plenary.—Sat., June 16, to Sat., June 23, in Vienna. Organised in Austria by the Oesterreichischen Nationalkomitees der Weltkraftkonferenz Schwarzenbergplatz 1, Vienna 1. Apply to Mr. C. H. Gray, secretary, World Power Conference, 201–202 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966. See ENGINEERING, February 11, 1955, page 168, and February 25, 1955, page 249.

Building and Public Works Exhibition, Second.—Sat., June 16, to Thurs., June 28, in Paris. *Agent:* R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

American Society for Testing Materials.—*Annual Meeting:* Sun., June 17, to Fri., June 22, at Atlantic City, N.J. Held in association with the Exhibit of Testing and Scientific Apparatus. *Pacific Coast National Meeting:* Sun., Sept. 16, to Sat., Sept. 22, at the Hotel Statler, Los Angeles, Calif. Offices of the Society: 1916 Race-street, Philadelphia 3, Pa., U.S.A.

Testing and Scientific Apparatus and Laboratory Supplies, 12th Exhibit of.—Sun., June 17, to Fri., June 22, at Atlantic City, N.J. Organised by the American Society for Testing Materials in connection with their Annual Meeting. Offices of the Society: 1916 Race-street, Philadelphia 3, Pa., U.S.A.

Civil Engineering Problems in the Colonies, Conference.—Mon., June 18 to Fri., June 22, at Institution of Civil Engineers, Great George-street, London, S.W.1. Apply to the Secretary of the Institution at that address. Tel. WHItehall 4577.

Acoustics, Second Congress of International Commission on.—Mon., June 18, to Sun., June 24, at Cambridge, Mass., U.S.A. Apply to Professor P. Fleury, International Union of Pure and Applied Physics, 3 Boulevard Pasteur, Paris 15e.

Automation, International Congress on.—Mon., June 18, to Sun., June 24, at the Conservatoire National des Arts et Métiers, 292 Rue Saint-Martin, Paris, 3ème. Apply to the Congress Secretariat at that address.

Manufacture of Paper and Associated Materials for Illustration Work, Fifth International Exhibition.—Fri., June 22, to Sat., June 30, in Paris. Apply to the secretary-general, Salon International des Techniques Papetières et Graphiques, 40 Rue du Colisée, Paris, 8e.

Machine Tool Exhibition, International.—Fri., June 22, to Fri., July 8, at Olympia, London, W.14. Organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. Tel. HOLborn 4667.

Trieste International Trade Fair, Eighth.—Sun., June 24, to Sun., July 8, at Trieste. *Agents:* Italian Chamber of Commerce for Great Britain and British Commonwealth, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

Colonial Highways Problems, Round Table Conference on.—Mon., June 25, to Wed., June 27, at the Institution of Civil Engineers, Great George-street, London S.W.1. Organised in conjunction with the Colonial Office. Apply to the secretary of the Institution at the above address. Tel. WHItehall 4577.

International Association of Bridge and Structural Engineering. Fifth International Congress.—Mon., June 25, to Mon., July 2, at Lisbon, Portugal. Apply to Mr. L. Gretener, secretary of the Association, Swiss Federal Institute of Technology, Zürich, Switzerland.

***Instrumentation, Telemetering and Automatic Process Control, Summer School.**—Mon., June 25, to Fri., July 13, at Northampton Polytechnic. Apply to the Principal, Northampton Polytechnic, St. John-street, London, E.C.1. Tel. CLErkenwell 5231.

***Cybernetics Congress.**—Tues., June 26, to Fri., June 29, at Namur, Belgium. Sections on Automation and Mechanical Brains. Organised in co-operation with the Belgian Ministry of Education and U.N.E.S.C.O. Apply to the Commercial Department, Belgian Embassy, 103 Eaton-square, London, S.W.1 (Tel. SLOane 9271); or to the Congrès International de Cybernétique 13 Rue Bass-Marcelle, Namur, Belgium.

Glass Congress, Fourth International.—Commencing Mon., July 2, at Paris. Apply to the secretary, Institut du Verre, 24 Rue Dourlet, Charleroi, Belgium.

***Works Transport Conference.**—Tues. and Wed., July 3 and 4, in Sheffield. Organised by the British Iron and Steel Research Association, 11 Park-lane, London, W.1. (Tel. GROsvenor 4751). Apply to the technical secretary, Plant Engineering Division, B.I.S.R.A., 140 Battersea Park-road, London, S.W.11. Tel. MACaulay 4421.

***Royal Agricultural Show.**—Tues., July 3, to Fri., July 6, at Newcastle-upon-Tyne. Organised by the Royal Agricultural Society of England, 35 Belgrave-square, London, S.W.1. Tel. BELgravia 5323.

International Union of Forest Research Organisations, 12th International Congress.—Fri., July 6, to Sat., July 14, at Oxford. Apply to Professor A. de Philippis, Instituto di Selvicoltura, Piazzale delle Cascine, Florence, Italy.

New York Lamp Show.—Sun., July 8, to Fri., July 13, at New Yorker Hotel, New York. Apply to Mr. George F. Little, 220 Fifth-avenue, New York 1.

Duke of Edinburgh's Study Conference on Human Problems of Industrial Communities within the Commonwealth and Empire.—Mon., July 9, to Fri., July 27, at Oxford.

Great Yorkshire Agricultural Show.—Tues., July 10 to Thurs., July 12, at Harrogate. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

***Physics of Some New Aspects of Non-Destructive Testing, Conference.**—Wed., July 11, to Sat., July 14, at the H. H. Wills Physical Laboratory, Bristol. Organised by the Non-Destructive Testing Group of the Institute of Physics, 47 Belgrave-square, London, S.W.1. (Tel. SLOane 9806). Apply to Mr. R. S. Sharpe, Bristol Aero-Engines, Ltd., Filton House, Bristol.

Molecules in Cosmic Sources, Seventh International Astrophysical Symposium on.—Thurs., July 12, to Sat., July 14, at Liége, Belgium. Apply to Prof. Harold C. Urey, Institute for Nuclear Studies, University of Chicago, Chicago 27, Ill., U.S.A.

Industrial Co-Partnership Association's 26th Summer Conference.—Fri., July 13, to Mon., July 16, at Girton College, Cambridge. Apply to the Industrial Co-Partnership Association, 36 Victoria-street, London, S.W.1. Tel. ABBey 3342.

International Society of Photogrammetry, Eighth Congress.—Tues., July 17, to Thurs., July 26, at Stockholm. Apply to Mr. P. O. Fagerholm, Brageväegen 8, Stockholm, Sweden.

Housing and Town Planning, International Congress.—Sun., July 22, to Sat., July 28, at Vienna. Apply to Mr. H. van der Weijde, secretary-general to the Federation of Housing and Town Planning, Paleisstraat 5, The Hague, Holland.

Royal Welsh Agricultural Show.—Wed., July 25, to Fri., July 27, at Rhyl. Apply to the secretary, the Royal Welsh Agricultura Society, Queen's-road, Aberystwyth. Tel. Aberystwyth 7551.

Australian World's Fair.—Thurs., July 26, to Sat., Aug. 4, at Sydney. Apply to the managing director, Australian World's Fair, 234 Clarence-street, Sydney, N.S.W., Australia.

***Dornbirn International Export and Samples Fair.**—Fri., July 27, to Sun., Aug. 5, at Dornbirn, Austria. Apply to the British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

Skane (Swedish National) Fair.—Sat., July 28, to Sun., Aug. 5, at Malmo. Apply to Skanemassan Kommissariat, Stora Nygatan 15, Malmo, Sweden.

Geographical Congress.—Thurs., Aug. 9, to Sat., Aug. 18, at Rio de Janeiro, Brazil. Apply to Mr. G. H. T. Kimble, International Geographical Union, 330 West Forty Second-street, New York 36.

***X-Ray Microscopy and Microradiography, Symposium on.**—Thurs., Aug. 16 to Tues., Aug. 21, at the Cavendish Laboratory, Cambridge. Held under the auspices of the International Union of Pure and Applied Physics, with financial support from U.N.E.S.C.O. Apply to the organiser, Dr. W. C. Nixon, Cavendish Laboratory, Cambridge. Tel. Cambridge 54481.

Radio Show (23rd Annual National Radio and Television Exhibition).—Wed., Aug. 22, to Sat. Sept. 1, at Earl's Court, London, S.W.5. Preview for overseas and special guests, Tues., Aug. 21. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

***"Model Engineer" Exhibition.**—Wed., Aug. 22, to Sat., Sept. 1, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Organised by *The Model Engineer* (Percival Marshall & Co., Ltd.), 19-20 Noel-street, London, W.1. Tel. GERrard 8811.

***Canadian National Exhibition.**—Fri., Aug. 24, to Sat., Sept. 8, at Toronto. A stand illustrating the United Kingdom's post-war scientific and technical achievements is being arranged by the British Government. Examples of automation equipment will be included in this display. Apply to the Board of Trade, Horse Guards-avenue, London, S.W.1.

International Society of Soil Science ... th International Congress.—Wed., Aug. 29, to Sat., Sept. ... in Paris. Organised by the International Society of Soil ...ence, Royal Tropical Institute, 63 Mauritskade, Amsterdam, Holland.

British Association Meeting.—Wed., Aug. ... to Wed., Sept. 5, in Sheffield. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109.

Foundry Trades Fair, International (GIFA).—Sat., Sept. 1, to Sun., Sept. 9, at the Fair Halls, Düsseldorf. To be held in connection with the 23rd International Foundry Congress. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576. See ENGINEERING, October 21, 1955, page 565.

Strasbourg European Fair, 31st.—Sat., Sept. 1, to Sun., Sept. 16, at Strasbourg. *Agent:* R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

St. Erik's Fair.—Sat., Sept. 1, to Sun., Sept. 16, at Stockholm. *Agents:* Thirza West Publicity Ltd., 141 New Bond-street, London, W.1. Tel. MAYfair 3701.

Leipzig International Autumn Fair.—Sun., Sept. 2, to Sun., Sept. 9, Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

Frankfurt International Autumn Fair.—Sun., Sept. 2, to Thurs., Sept. 6, at Frankfurt. *Agents:* Lep Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Farnborough Flying Display and Exhibition.**—Mon., Sept. 3, to Sun., Sept. 9, at Farnborough, Hampshire. Open to the public on Fri., Sat., and Sun., Sept. 7, 8 and 9, only. Organised by the Society of British Aircraft Constructors, Ltd., 29 King-street, London, S.W.1. Tel. TRAfalgar 3231.

Applied Mechanics, Ninth International Congress.—Wed., Sept. 5, to Thurs., Sept. 13, at Brussels. Apply to the general secretariat, Université Libre de Bruxelles, 50 Avenue F. D. Roosevelt, Brussels, Belgium.

***Radio and Television Exhibition.**—Wed., Sept. 5, to Sat., Sept. 15, in Paris. Organised by the Syndicat des Constructeurs d'Appareils Radio Recepteurs et Televiseurs, 23 Rue de Lubeck, Paris, 16e.

***Cologne International Autumn Fair.**—*Household goods and hardware:* Fri., Sept. 7, to Sun., Sept. 9, at Cologne. *Textiles and clothing:* Sun., Sept. 16, to Tues., Sept. 18, at Cologne. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

***Levant Trade Fair, 20th.**—Fri., Sept. 7, to Tues., Sept. 25, at Bari. Apply to the Italian Chamber of Commerce for Great Britain and the Commonwealth, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

***Ghent Fair, 11th International.**—Sat., Sept. 8, to Sun., Sept. 23, at Ghent, Belgium. *Agents:* S. R. Tippett & Co., Ltd., 110 Cannon-street, London, E.C.4. (Tel. MANsion House 4500); and Robertson, Buckley & Co., Ltd., Berey's Buildings, George-street, Liverpool (Tel. Central 0952).

Swiss National Autumn Fair (Comptoir Suisse).—Sat., Sept. 8, to Sun., Sept. 23, at Lausanne. Apply to the commercial secretary, Swiss Legation, 18 Montague-place, Bryanston-square, London, W.1. Tel. PADdington 0701.

German Agricultural Show.—Sun., Sept. 9, to Sun., Sept. 16, at Hanover. Apply to the Deutsche Landwirtschafts-Gesellschaft, Niedenau 48, Frankfurt-on-Main.

High-Speed Photography, Third International Congress and Exhibition.—Mon., Sept. 10, to Sat., Sept. 15, at Government Offices, Horse Guards-avenue, London, S.W.1. Sponsored by the Department of Scientific and Industrial Research. Apply to the Congress Secretariat, D.S.I.R., Charles House, 5-11 Regent-street, London, S.W.1. Tel. WHItehall 9788. See ENGINEERING, November 11, 1955, page 671.

***Fishery Equipment Exhibition, International.**—Sat., Sept. 15, to Sat., Sept. 22, at Istanbul, Turkey. Organised by the Government of Turkey to coincide with the fourth meeting of the General Fisheries Council for the Mediterranean to be held at Istanbul from Sept. 17 to 22. The Council is sponsored by the Food and Agriculture Organisation of the United Nations. Apply to Mr. Cihat Renda, Meat and Fish Office, Selanik Cad. 78, Ankara, Turkey.

***Business Efficiency Exhibition.**—Tues., Sept. 25, to Fri., Sept. 28, at St. Mary's Drill Hall, Southampton. Organised by the Office Appliance and Business Equipment Trades Association, 11–13 Dowgate-hill, Cannon-street, London, E.C.4. Tel. CENtral 7771.

***Chemists' Trade Fair, International, (INDROFA).**—Sun., Oct. 7, to Sun., Oct. 14, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany. *Agents:* John E. Buck and Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

***Motor and Cycle Show.**—Thurs., Oct. 4, to Sun., Oct. 14, in Paris. Representative: R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

"Safe at Work" Exhibition.—Mon., Oct. 8, to Wed., Oct. 10, at the Sophia Gardens Pavilion, Cardiff. Organised by the Cardiff and District Industrial Safety Committee of the Royal Society for the Prevention of Accidents. Offices of the Society: 52 Grosvenor-gardens, Westminster, London, S.W.1. Tel. SLOane 2246.

Engineering Industries Association: London Regional Display.—Wed., Oct. 10, to Fri., Oct. 12, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Association, 9 Seymour-street, London, W.1. Tel. WELbeck 2241.

***Building Trades Exhibition.**—Tues., Oct. 16, to Sat., Oct. 27, at Manchester. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

Knitting Machinery and Accessories Exhibition.—Wed., Oct. 17, to Sat., Oct. 27, at Leicester. Organised by Textile Recorder Exhibitions Ltd., Old Colony House, South King-street, Manchester 2. Tel. Blackfriars 7234.

***Charleroi Trade Fair.**—Oct. 27 to Nov. 11, at Charleroi, Belgium. *Agent:* Mr. Vincent Caers, 67 Rue ... avenue, Wembley, Middlesex. Tel. Wembley 0975.

***Chemical Industry, Rubber and Plastics Exhibition.**—Thurs., Nov. 22, to Mon., Dec. 3, in Paris. ... Butler's Advertising Service, 22 St. Giles High-street, ...ondon ,W.C.2. Tel. TEMple Bar 5905.

United States World Trade Fair.—Sun., ... 14, to Sat., April 27, 1957, at the New York Coliseum, ... York. Managers: The Charles Snitow Organisation, Inc., ... Madison-avenue, New York 17. Information may ... obtained from the British Commonwealth Chamber of ... erce in the United States, 677 Fifth-avenue, New York, ... from the Fair' House, 36 and 38 Southampton-street, London, W.C.2. ... British and Commonwealth Office, ... TEMple Bar 8947

MECHANICAL HANDLING

—MAST AND MARSHALLING EQUIPMENT

Concluded from page 378

Scale models of civil engineering projects, including the construction of the Chapel Cross, Dumfriesshire, atomic power station and the Cluanie dam in Inverness, were among the items shown on the stand of Mitchell Engineering Limited, 1 Bedford-square, London, W.C.1.

RETRACTABLE MAST

Mitchell Engineering Limited also showed the Leroy retractable mast (Fig. 16), a three-sided articulated chain which is wound flat on to a drum when not in use. An electric motor operating through a reduction gear unit unrolls the links from the drum and, as the links travel through curved guides, the two outer sections swing inwards and join together to form a rigid

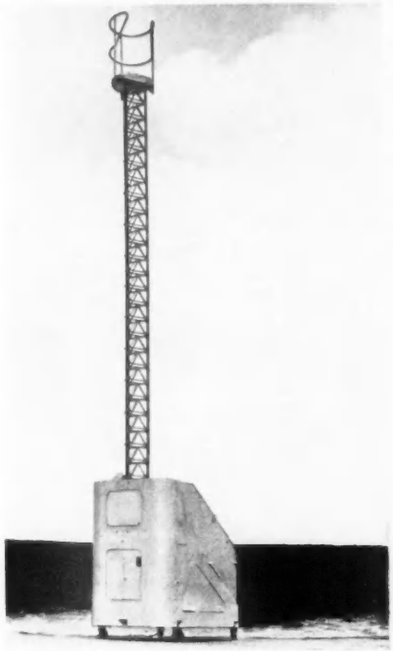


Fig. 16 The Leroy retractable mast: Mitchell Engineering Ltd.

triangular mast. A prototype was described in ENGINEERING, vol. 177, page 244 (1954).

The mast can be raised vertically at 15 ft. per minute to a maximum height of 50 ft. The overall dimensions of the complete unit with the mast retracted are: width, 5 ft. 2 in.; length, 8 ft. 10 in.; height, 7 ft. 6 in.; weight, 2½ tons.

The mast dispenses with time-wasting erection tackle, such as ladders, scaffolding, bosuns' chairs, etc., and has many uses, both indoors and outdoors where men have to work aloft up to heights of 50 ft. It can be used for the following purposes: repair and maintenance of street lights and overhead power systems; cleaning of walls, roofs and skylights; the inspection and servicing of aircraft and hangars; work on ships' hulls in dry dock; fire fighting towers; television and motion camera towers.

WAGON MARSHALLING SYSTEM

A model of a mechanical wagon-marshalling system, typical of the systems in operation at the National Coal Board central coal-preparation plant at Philpstoun, Linlithgow, Scotland, and at the Central Electricity Authority power station at Leicester, was also shown by Mitchell's. Both of these were described in ENGINEERING, vol. 178, page 377 (1954).

By means of this marshalling system, which is designed to replace the conventional method of handling wagons in marshalling sidings by shunting and manhandling, trains of wagons can be handled by push-button control. The incoming wagons are taken from sidings by mechanical handling plant and are loaded or unloaded, weighed and returned to the same sidings, or to others as necessary, without the use of locomotives or capstans.

Being operated mechanically, it is safer than the conventional shunting system and can be worked in all kinds of weather. An added advantage is that wagons can be handled at a rate well beyond the capacity of standard "balloon" sidings—a thousand tons of coal an hour or more can be handled with the Mitchell system.

A working model of wagon marshalling equipment was also displayed by the Fraser and Chalmers Engineering Works of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. This equipment, designed to facilitate the movement of wagons on and off the wagon tippler for unloading bulk materials, consists essentially of three units. The first unit advances a waiting train of full wagons by one wagon length; the second unit engages the leading wagon of the full train and marshalls it on to the tippler cradle, at the same time displacing any empty wagon that may be there; the third unit moves forward the previously-discharged empty wagon, and any other empty wagons, into the "empties" sidings. The first and last units run on auxiliary tracks between the main rails and are driven by haulage winches. The intermediate unit is hauled by chain and runs on an auxiliary track on one side of the main rails.

NON-SLIP POWER TRANSMISSION BELT

A new type of non-slip power-transmission belt (Fig. 17) with a positive engagement with the pulleys, manufactured in the United Kingdom by the North British Rubber Company, Edinburgh, under licence from the United States Rubber Company, New York, was shown on the stand of the former company.

The PowerGrip belt, as it is known, is an unusually thin belt, having as its load-carrying element a single layer of continuously wound high-tensile wire cable, moulded in Neoprene. Based on this tension member are moulded equally-spaced Neoprene teeth. A jacket of Neoprene-impregnated fabric provides a wear-resistant surface for the teeth as well as protection for the tension member. This design makes it possible to maintain constant tooth spacing, or pitch, to ensure accurate and positive engagement of the teeth with axially-cut grooves in pulleys having the same pitch.

Because of its construction, this new drive covers a speed range varying from inches per day to 16,000 ft. per minute, and will transmit powers ranging from $\frac{1}{100}$ to over 300 h.p.

The belt does not stretch and is therefore ideal for fixed centre drives. At the same time more compact drives are practicable and ratios up to 30 to 1 are made possible. Moreover, the extreme flexibility of the belt permits pulley diameters as small as ½ in. to operate at 10,000 r.p.m. even under heavy-load conditions.

These features permit economies in bearing design since bearing loads are reduced through the absence of the initial tension which is required in all other belt drives to provide a positive grip between belt and pulleys. No lubrication or belt dressing is required, yet oil has no effect on the belt. In addition, the belt is extremely quiet in operation.

This drive has a high mechanical efficiency, because there are no friction-creating joints, no lubrication losses, and practically no heat is generated in operation.

TAPE-CONTROLLED CRANE

The ability of an automatically-controlled overhead crane to conform to a complex pre-selected sequence of movements was demonstrated by its manufacturers, the Vaughan Crane Company, Limited, West Gorton, Manchester, 12, by causing it to play a game of chess. The sequencing was controlled by a magnetic tape.

The equipment comprises a set of frequency generators, operated by a series of push buttons to set up the required series of load movements on the crane. These are recorded and stored on magnetic tape. When required, the recordings are "played back," and the signals transmitted through suitable frequency selectors to the contactor gear operating the crane. A sequence of approximately 60 minutes duration may be recorded on a single tape. Alternatively, a shorter sequence can be recorded on continuous tape, and thus provide continuous crane operation for as many hours as desired. This control equipment is applicable to any type of crane on which a repeatable cycle of operations is desired. Load handling can be by means of a magnet as in the demonstration, or, by using automatic lifting tongs on the crane hook.

LIGHT TOWER CRANE

The light tower crane exhibited by Butters Brothers and Company, Limited, MacLellan-street, Glasgow, S.1, which occupied a dominant position in the main hall, is said to be the first of its kind manufactured to a British design; hitherto such cranes, of Continental design, have been manufactured in the United Kingdom under licence. Designed for easy and rapid erection, the Butters Monotower crane has a height of 90 ft. to the jib heel pin, with a 75 ft. jib. It operates on rail track at 12 ft. centres, with a minimum radius on curved tracks of 14 ft. 6 in. on the inner rail.

The load capacities are as follows: 3 tons at 30 ft. radius, 2 tons at 48 ft. radius, and ¾ ton at 80 ft. radius. Carrying a 3 ton load, the crane is capable of hoisting at 60 ft. per minute, derricking at 45 ft. per minute, and slewing at ¾ r.p.m. The hoisting speed with a 1 ton load is 180 ft. per minute. Driven by two 6 h.p. motors, the crane has a travelling speed of 70 ft. per minute. The hoisting and derricking motors each develop 17½ h.p. and slewing is by a 5 h.p. motor. All motors operate from standard alternating-current supplies.

There are two operating platforms, one at the bottom of the mast and one at a higher level

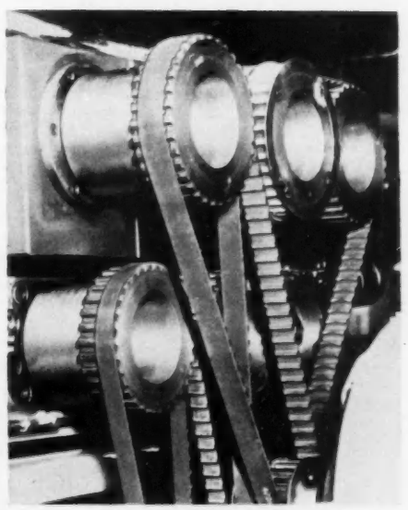


Fig. 17 The PowerGrip belt has a high-tensile load-carrying wire cable moulded in Neoprene on which are moulded equally-spaced Neoprene teeth: North British Rubber Co.

Fig. 18 6 ton full-circle slewing crane with telescopic jib: F. Taylor and Sons (Manchester) Ltd.

giving optimum visibility. Control is electrical from both platforms.

6 TON SLEWING CRANE WITH TELESCOPIC JIB

The 6 ton slewing crane (Fig. 18) shown by Taylor and Sons (Manchester), Limited, Bolton-road, Salford, 6, Manchester, is designed to operate under low headroom (11 ft. 7 in.) when working at maximum load and jib horizontal. It has a safe working load of 6 tons at 10 ft. radius and 3 tons at 19 ft. radius. It is capable of travelling at low speeds when loaded; the craning operations may be carried out either from the cab or from a seat positioned on the rotating crane superstructure. Outriggers are not required in any position. The crane has a maximum lift of 21 ft., and is capable of raising maximum loads from 38 ft. below ground level. Full-circle slewing is by a two-cylinder hydraulic motor.

The main jib is in the form of a hollow square beam and an inner jib mounted on slides has an outward movement of 9 ft. carrying the hook assembly with it. It is actuated by a double-acting hydraulic ram. The hook remains in the same relative position to the jib during telescoping by means of a compensating device.

A dual Deri-Sine hydraulic pump is mounted on the chassis, and the drive incorporates a Warner clutch. The larger pump feeds the hoist motor only, while the smaller pump is used to power the luffing, slewing and telescoping services; thus hoisting and any one of the other services can be carried out simultaneously at full speed.

The Taylor company were also showing a new mobile 2 ton crane (at 12 ft. 2½ in. radius), capable of slewing through 200 deg., and designed primarily to operate with an hydraulic grab. An optional front-jib fitment with an hydraulic ram gives a hook traverse of 4 ft. with the jibs horizontal. The maximum load can be lifted 16 ft.

PACKAGED CRANE SET

A crane built from a kit of standard components was shown by Doity Cranes Limited, 4, St. Mary's Parsonage, Manchester, 3. The kit (Fig. 19) contains all the electrical, mechanical and structural details needed to build the end-carriages of an electric travelling overhead crane. It can also be used as a crab mounting for a hoist.

A patent system of axle alignment has made it possible to design the kit so that all precision work is produced in advance at quantity manufacturing costs. The manufacturers claim that with this kit, a travelling bridge for an overhead crane can be completed in less than 60 man hours after the main structure has been made.

The kit includes half a ton of prepared steel sections which are also used as a steel container for the remaining components. The side members are bored for axles at varying centres for up to 55 ft. spans. The maximum capacity of each trackwheel is 6 tons.

The trackwheels themselves are of newly developed hard-wearing material with wide treads in accordance with the recent research recommendations, and are fitted with roller and ball-thrust bearings.

Other interesting crane exhibits included a new Diesel-driven mobile crane by R. H. Neal and Company, Limited, Plant House, Ealing, London, W.5, with a capacity of 6 tons with outriggers and 4 tons when fully mobile, available with jibs up to 60 ft. long. This crane is fitted with a new type of hoist unit, hydraulic controls and a differential drive.

British Insulated Callender's Cables, Limited, 21 Bloomsbury-street, London, W.C.1, were showing their newly-developed guarded-conductor current-collection system for cranes and conveyors; and crane control gear was demonstrated by the Igranic Electric Company, Limited, Bedford, on a $\frac{1}{12}$ scale model of a 10 ton electric derricking crane with a scale model Igranic 77 in. circular lifting magnet, both of which were operated by full-scale gear comprising hoist and traverse panels, lifting magnet control panel and master switches.

The largest lifting equipment on view, displayed by the Wharton Crane and Hoist Company, Limited, Reddish, Stockport, Cheshire, was the 100 ton overhead electric travelling crane with a three-motor crab with an auxiliary hoist of 15 tons. This unit, weighing about 27 tons, was manufactured for the Central Electricity Authority's Bold " B " power station.

Fig. 19 Packaged end-carriage for electric travelling overhead crane: Doity Cranes, Ltd.

A BRIGHT NICKEL PLATING PROCESS

Of late years the shortage of metal polishers and the increasing adoption of automatic electric plating equipment have created a need for efficient bright nickel-plating processes and, to meet this demand, W. Canning and Company, Limited, Great Hampton-street, Birmingham 18, have introduced their Nimax process which is now commercially available to industry. This bright nickel-plating process combines good mechanical properties with effective surface levelling and high brilliance. It is stated to be economical in operation and suitable for iron, steel, brass, copper and other common metals

Fig. 1 Nimax bright-nickel deposit on a dome after a No. 180 emery finish. The levelling properties and brilliance are well shown.

Fig. 2 A severe test for adhesion and ductility. This wheel rim was plated, cut and subjected to severe twisting. The deposit withstood the distortion without cracking or failure.

and alloys, including zinc-base die-cast alloys, the latter after copper plating. We are informed that its throwing and covering powers are exceptionally good and, moreover, that the levelling and scratch-filling properties of the deposit permit the preliminary polishing of the articles to be reduced to a minimum. In addition, the deposit is free from surface passivity, thus enabling direct chromium plating to be carried out without the necessity for surface activation. Prolonged tests have shown that the deposits possess high ductility which is of importance in subsequent fabrication.

The plating solution is used in rubber-lined baths and is operated at a temperature of between 120 and 130 deg. F., at a current density of from 36 to 60 amperes per sq. ft. The solution is simple to maintain but requires the use of a single addition agent, termed Syn. Its operating *p*H value of from 4 to 4·5 minimises the dissolution of any exposed unplated metal and thus reduces very materially any subsequent metallic contamination of the electrolyte.

In Parliament

INFORMATION ON AUTOMATION

At a recent sitting of the House of Commons, Mr. C. Osborne (Conservative) asked for information about the number of persons likely to be directly affected in their employment by automation, and inquired whether the resources of the Central Office of Information could be used to explain the facts of the situation to those workpeople who were directly concerned. In reply, Mr. Iain Macleod, the Minister of Labour and National Service, said that the development of automation would probably continue to be gradual, but it was not possible to forecast the rate at which it would be introduced or the number of workers whose employment might be affected.

With regard to the part that might be played by the Central Office of Information, it was the intention of the Government to make factual information about automation generally known. Mr. Macleod said that, as he had recently informed the House, it was for individual firms which were contemplating the introduction of automation to consider how it would affect their workpeople and to bring them into the discussions on the subject as early as possible. (This was reported in our issue of May 18, page 383).

NATIONAL SCIENCE CENTRE

In his capacity of representative of the Lord President of the Council, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Works, was asked about the Government's plans for the establishment of a National Science Centre. Mr. Bevins told Mr. F. T. Willey (Labour) that it was announced in 1952 that the planning of the Science Centre had had to be deferred and, unfortunately, that position was still unchanged. Plans for a new Patent Office and Scientific Reference Library on the South Bank of the Thames were, however, under discussion between the Government Departments concerned.

As to the estimated capital expenditure required for the provision of adequate accommodation for a national reference library of science and invention, for which Mr. Willey had also asked, Mr. Bevins said he was unable to add anything to the answer which he gave in November last.

It may be noted that, in that answer, Mr. Bevins stated that the establishment of a national reference library of science and invention was necessarily bound up with the future of the Patent Office building. The capital cost of a new building to house both the Patent Office and its library, extended to provide the coverage of a national reference library, was estimated at rather more than £2 million, excluding the cost of the site. It was difficult to give a separate estimate of the share of the library in the total cost, but it would take up rather more than half of the total accommodation.

WORK OF RESEARCH ASSOCIATIONS

Also on behalf of the Lord President of the Council, Mr. Bevins was asked how far it was the policy of the Government to encourage research associations to undertake development work. He told Mr. James Callaghan (Labour), who raised the matter, that development work was an important part of the activities of research associations, which the Government encouraged by means of grants paid by the Department of Scientific and Industrial Research. Those grants supplemented the contributions made by industry. The resources devoted to development were decided by the councils of the associations, which were made up predominantly of industrialists, but included representatives of the D.S.I.R. The associations as a whole spent approximately one-quarter of their budgets, or more than £1 million, on development.

Asked whether, in view of the national scarcity of scientific manpower, it would not be wise to encourage much more development work to be undertaken through the research associations for the benefit of industry generally, Mr. Bevins gave an assurance that the Lord President was very well aware of the recommendation made by the Advisory Council on Scientific Policy. Several development companies had already been formed by research associations. In addition to that, the Government were starting to try out civil development contracts with scientific research associations.

ELECTRICITY FROM ATOMIC ENERGY

Information as to the progress which has been made by the United Kingdom Atomic Energy Authority in its research into methods of cheapening the unit cost of electricity produced by nuclear power was sought by Mr. Geoffrey Wilson (Conservative). Mr. R. A. Butler, the Lord Privy Seal, said that the Authority was carrying out research on a number of reactor systems of advanced design, but that it was too early to forecast the cost of electricity produced from them. He agreed that he had seen an article in the Press suggesting the possibility of producing electricity at a cost of less than the 0·6*d.* a unit previously mentioned. It was an interesting article but it probably erred on the side of optimism. An accurate forecast could not be given because account had to be taken of the stations which might be established after 1960.

Mr. William Warbey (Labour) asked whether, in considering costs, it had now been decided to increase the amount of credit allowed for the plutonium by-product, since the market rates fixed by the United States for uranium 235 were higher than those allowed for in British estimates. Mr. Butler said he would require to study the details involved in the matter before giving a considered reply.

Nuclear Energy Developments

Mr. Butler was asked by Mr. James Callaghan (Labour) what further information on recent developments in atomic research British scientists might make available, in view of Mr. Kurchatov's recent address at Harwell. The Minister replied that the policy governing release from security restrictions of information in this connection was under constant review and the range covered by such restrictions was being progressively reduced. Work in the thermonuclear field was released to the universities and to other interested bodies progressively and subject only to certain conditions of security.

Military Aircraft Projects

A statement by the Minister of Supply on the development of his policy to reduce the number of projects supported by his Department in the aircraft industry, was asked for by Mr. George Brown (Labour). In reply, Mr. Reginald Maudling said that, including the cancellations referred to by him in the defence debate, work had been stopped on more than a dozen projects during the past year and the scale of other projects had been reduced. He would continue to keep a close watch on the whole programme, with a view to securing any further reliefs which might be available. When new projects were proposed, particular care was taken to see that they were within the capacity of the industry.

P.1. Aircraft in Production

Mr. Brown inquired when it was expected that the P.1. aircraft would be put into squadron service with the Royal Air Force, and Mr. R. R. Stokes (Labour) asked what orders had so far been placed for these aircraft for use by the Naval Air Arm. Mr. Maudling said that a limited production order was placed in October and November last year, to cover jigging and tooling, for meeting the estimated requirements of the R.A.F., and for long-dated materials to cover the initial requirement. A further order would be placed as soon as that was desirable. He was not prepared at that stage to state when these aircraft would be in squadron service with the R.A.F., and the Admiralty had no requirement for them.

Steel Plate Supplies

Concern continues to be expressed by Members at the shortage of steel plates. Mr. F. T. Willey (Labour) asked the President of the Board of Trade what progress had been made for the provision of additional rolling capacity to increase supplies. He was told by Mr. A. R. W. Low, Minister of State to the Board of Trade, that the Iron and Steel Board expected that the production of steel plates during the current year would be about 150,000 tons above the total for 1955. The Iron and Steel Board was reviewing with the steel producing firms the question of providing additional capacity for the production of steel plates. In another answer to Mr. Willey, the Minister said that he was not aware that supplies were being distributed inequitably.

Aid for the National Coal Board

According to a written answer by Mr. Henry Brooke, the Financial Secretary to the Treasury, issues from the Consolidated Fund to the Minister of Fuel and Power, for the financial assistance of the National Coal Board, are estimated to amount to about £70 million during the financial year 1956-57. He informed Sir Alfred Bossom, Bt. (Conservative) that, according to present expectations, the corresponding amount for the financial year 1957-58 was likely to be of about the same magnitude.

Compensation for Mining Subsidence Damage

Mr. S. T. Swingler (Labour) urged that, in drawing up the proposed legislation on compensation for damage due to mining subsidences, the Minister of Fuel and Power should include provision for compensating victims who had to vacate their houses owing to serious damage. The Minister, Mr. Aubrey Jones, replied that these and similar matters were being considered, but that it was not possible to discuss technical details relating to an unpublished Bill.

Concessionary Coal

In a written reply, Mr. David Renton, Parliamentary Secretary to the Ministry of Fuel and Power, told Mr. P. F. Remnant (Conservative) that some 630,000 employees of the National Coal Board were entitled to supplies of coal free of charge or at cheap rates. The amount of such concessionary coal issued in 1955 totalled 5·1 million tons.

Irregular Electricity Supplies

Asked by Mr. G. P. Stevens (Conservative) what provision for damages caused by irregular supplies of electricity by an electricity board was contained in the regulations of the Minister of Supply under section 60 (1) of the Electricity Act, 1947, Mr. Renton said that there was no such provision. Compensation was a matter to be settled in the courts and the Minister had no power to make regulations. He agreed that all kinds of unfortunate consequences could follow as a result of power cuts and the occurtence of technical failures, but he felt that these matters were not ones which could be decided in advance by the making of complicated regulations.

Progress of Oil Refining Industry

Replying to Mr. Harold Davies (Labour), who desired information regarding the progress of the British oil-refining industry, Mr. Renton said that, between 1948 and 1955, the number of employees therein had more than doubled, and had increased during that period from 8,049 to 17,304. During the same eight years, the output of refined products had increased six-fold, from 4,426 thousand tons to 27,922 thousand tons.

Refuse-Extraction Machinery

Mr. Duncan Sandys, the Minister of Housing and Local Government, told Mr. Ronald Russell (Conservative) that he fully appreciated the importance of recovering valuable materials, and especially ferrous scrap, from refuse. At the same time, he could not at present sanction loans to local authorities to enable them to install additional plant for that purpose.

THE HUMAN ELEMENT

Accidents cost more than strikes—Automation stands or falls on the shop floor—and Government cushion during changeover—West Indian employment commission—Continuity in the Colonial Service—Soviet release men for industry.

★ ★ ★

Accidents in Industry

The biggest source of broken time in industry is accidents, not strikes. The number of days lost to industry on account of incapacity to insured workers is just short of 20 million man days a year. Every day about 60,000 workers are absent owing to industrial injury. The accident rate has changed but little in recent years despite the increase in mechanisation, and only one accident reported in six is caused by power driven machinery. Most arise from such everyday causes as falls and handling goods.

This is one of those big problems which are very widely spread over industry and therefore do not make a repeated, insistent impact on management—like the toll of accidents on the roads to the general public. Nevertheless, it has brought about a report by a sub-committee of the National Joint Advisory Council, published last week. There are four main conclusions. First, that accidents can be prevented by positive action and are a reflection on efficiency when they happen. Second, safety must be a definite aim and the means created and used to secure it. Third, legislation must be kept up-to-date on the subject, although this is only a residual (though essential) part of national policy on the matter. Fourth, a more vigorous and sustained effort is needed by all concerned in planning and design to prevent accidents from happening.

Six principles are enunciated. Briefly, these are that accident prevention is part of good management and good workmanship, that both sides must co-operate to stop accidents, that top management must give a lead, that there must be a known safety policy in the works, that resources must be to hand to carry out that policy and that the best methods must be used.

★ ★ ★

Exchanging Views on Automation

The seminar held at Transport House last week among European trade unions on the subject of automation proved to be a very commonsense affair. It came to the conclusion that there is a serious lack of information about the effect of automation on industry and it was decided to set up a central clearing house on the subject. Other points emphasised were the need for vocational training schemes, planning manpower problems as well as technical ones and the need for trade unions to negotiate on automation in advance of schemes going in and to get some of the benefits for their members.

So far so good: no one will quarrel with findings of that kind. It was noticeable, however, that much emphasis was laid on the possibility of dealing with automation problems at the top. It all depends what is meant by the " top." In a sense one might as well ask, how high is " up "? The recent trouble at Standard Motors showed that lack of negotiating finesse can develop at the top if by that is meant negotiating with top management of a company. If by " top " is meant the top of the union or of the trade union movement, then there are serious dangers to be watched. Broad principles can be thrashed out and talked about with a good deal of publicity at that level, and so far as it goes (which may not be far) that is all to the good. But the place where automation problems will be really tackled is on the shop floor. Where management-relations are bad in a factory, automation will be made the occasion for all sorts of trouble. That fact should be given wide currency now before discussion of this much over-worked and mis-used word " automation " goes any further.

★ ★ ★

The Unions and the Report on Automation

The report on automation compiled by the Department of Scientific and Industrial Research has on the whole been very well received by the trade union movement. The conclusion that none of the social problems arising in the transition period " is unsurmountable, given wise management," and the emphasis on the need to consult the unions in advance of each step and to pay close attention to the feelings and problems of the workers affected, are well in line with the feelings expressed by organised labour. It remains to be seen how managements, and trade unions, will behave when face to face with actual problems of redundancy and re-training. To talk of " encouraging the mobility of labour " and " easier and cleaner work," " shorter hours " and the like will be quite meaningless unless the man who is losing his job is helped financially until he is satisfactorily re-settled somewhere.

The Electrical Trades Union's " terms for the introduction of automation," laid down at their annual conference at Hastings, do not, for all their aggressive tone, differ greatly from the recommendations of the D.S.I.R. report. Like Walter Reuther of the United States Automobile Workers, Mr. F. Foulkes of the E.T.U. is determined that the employer shall be financially responsible for his workers in the transition period. There is no intention to tolerate any loss of earnings, and the union are determined that the benefits of automation shall be shared by their members, through shorter hours, longer holidays and higher wages. Other unions, including the Post Office Workers, the Bank Employees, and the A.E.U., have made similar comments. None has yet taken a stand against automation: all are prepared to welcome it, provided their members are not made to suffer.

This attitude could, however, make it difficult for all but the largest companies to introduce labour-saving machinery at any time except during a boom, when redundant workers can be absorbed elsewhere. It is here that the Government may have a part to play in providing the necessary cushion to enable British industry to progress when its need may be greatest.

★ ★ ★

Short Time and the West Indians

Short-time working in the Birmingham-Coventry area increased sharply during the past two weeks. Mr. W. E. Davies, regional controller of the Ministry of Labour, announced after a meeting on May 15 of the Midland Regional Board for Industry that over 30,000 workers were on short time, 10,000 more than a fortnight previously. He pointed out that most of the increase was due to the effect of the Standard strike on other companies, and that a quick improvement was therefore likely. At the same time he said the Board expected a general increase in the number of workers placed on short time now that they are entitled to unemployment benefits. The total number of unemployed in the area has not risen and remains at about 15,000.

Immigrants from the West Indies who continue to arrive in the area are finding jobs harder to get. There are already some 18,000 West Indians who have settled there, more than in any other area in the country. The Speaker of the House of Representatives of Jamaica, Mr. B. B. Coke, and an elected member, Mr. T. N. Golding, explained on their visit to Birmingham last week that immigrants go mainly to the West Midlands and to London " not because they feel they cannot get work elsewhere but because they can be sure that they will find their own people there." So far only a very small percentage are unemployed but Mr. Coke recognised the need for more guidance for new arrivals. He will propose to his Government that they should send a Commission to Britain to study the problem and with the help of the British authorities, to find a way of reducing immigrants to " spread out " to other areas.

★ ★ ★

Pool of Overseas Civil Servants

Under the rather daunting title of " Statement of Policy Regarding Organisation in Her Majesty's Overseas Civil Service," the Government last week issued a White Paper of considerable importance to the colonies and to professional men, including engineers. Until comparatively recently, Government departments in the colonies (notably the public works departments) were important sources of employment to engineers and such men, like all overseas civil servants, are affected by the trend towards self-government in many of these territories.

The Government is to try to accomplish two things. They are to establish a pool of officers of the Overseas Civil Service who will be employed by the United Kingdom Government but who will be seconded to overseas Governments who may want their services for a certain period of time. Further, the Government is to make it possible for Government officials already in pensionable employment overseas to transfer to a special list which will make them servants of the United Kingdom Government for seconding to other overseas areas. Under the last arrangement officials would be paid pensions and any compensation obtained for them by the United Kingdom Government, the money being recovered from the Government employing them.

The scheme thus attempts to do two things. It hopes to secure for men who might be victims of constitutional change continuity in their careers—an excellent move, especially in an age when technical men are at a premium. Secondly, it tries to put at the disposal of overseas Governments a pool of trained personnel. This is also to be welcomed for such territories lack above all else access to good technical manpower.

★ ★ ★

Labour Shortage in the Soviet Union

The successful execution of the Soviet Government's Five-Year Plan—by far the most ambitious development programme of the century—is being seriously threatened by a shortage of manpower. The severe drop in the birth rate during the war is now being felt: industry will receive only 1·4 million recruits a year over the next five years, 600,000 less than the average during the past five years. The bringing into cultivation of virgin lands in Siberia and Central Asia will eventually require many times the 500,000 workers who have enrolled so far. The Government's policy to shorten working hours, to improve working conditions and to raise living standards is taxing the country's reserves of manpower to the limit.

In this context, the Soviet Government's decision to reduce the number of men under arms by 1·2 million over the next twelve months (in addition to the reduction of 640,000 announced last summer) is easy enough to understand. But even if less are employed in the Services, more will be needed to produce the equipment and plant the Government intend to export to compete with the West in the industrialisation of under-developed countries. The bulk of the saving will have to come from the replacement of men by machines. The Five Year Plan therefore envisages very rapid progress in mechanisation.

According to Mr. Harry Baker, a member of the Birmingham Trades Council delegation just back from a visit to Russia, Soviet workers welcome automation in their factories. The threat of unemployment is non-existent, industrial production is planned in long runs of standard items. Small wonder, therefore, that Dr. L. Hafstad, director of Research at General Motors, should say: " Our choice is brutally clear . . . we can either learn mathematics and science—or Russian."

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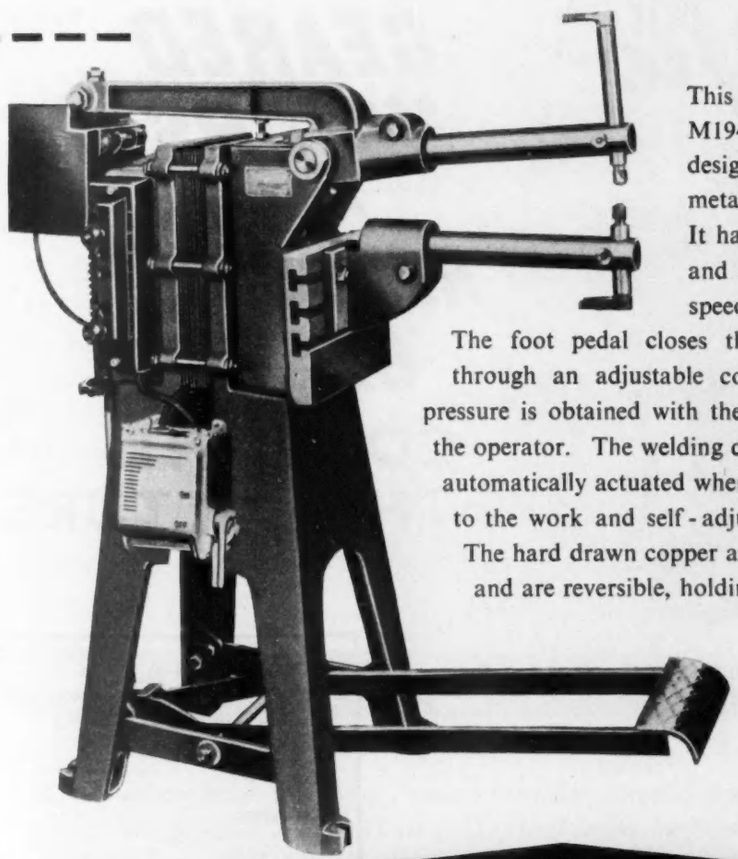

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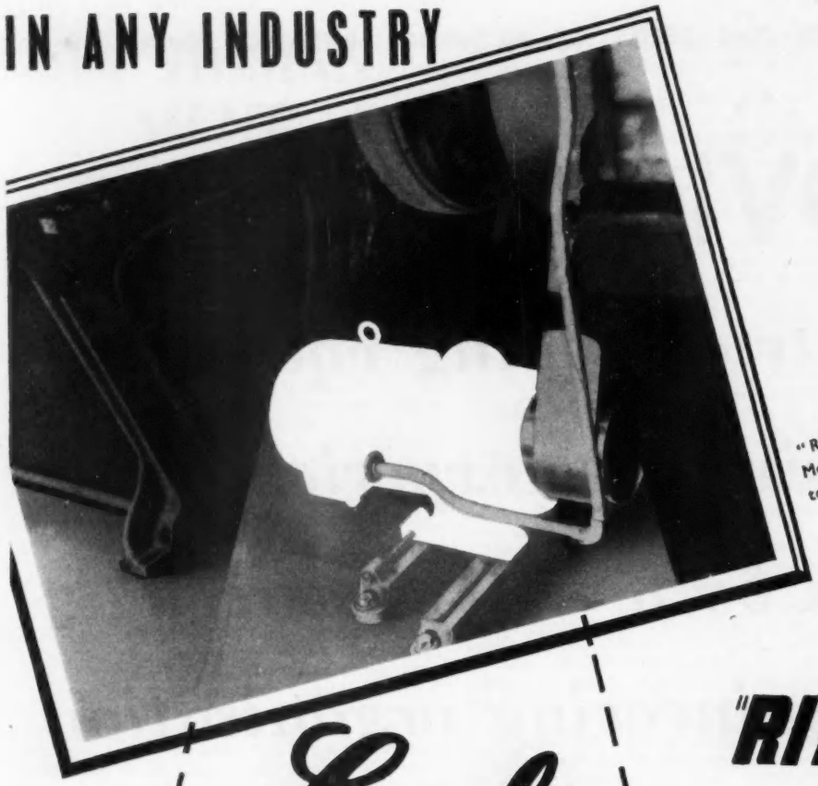

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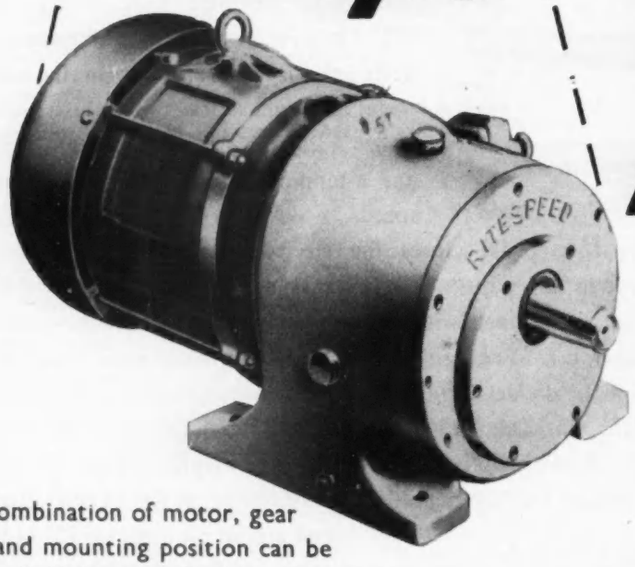

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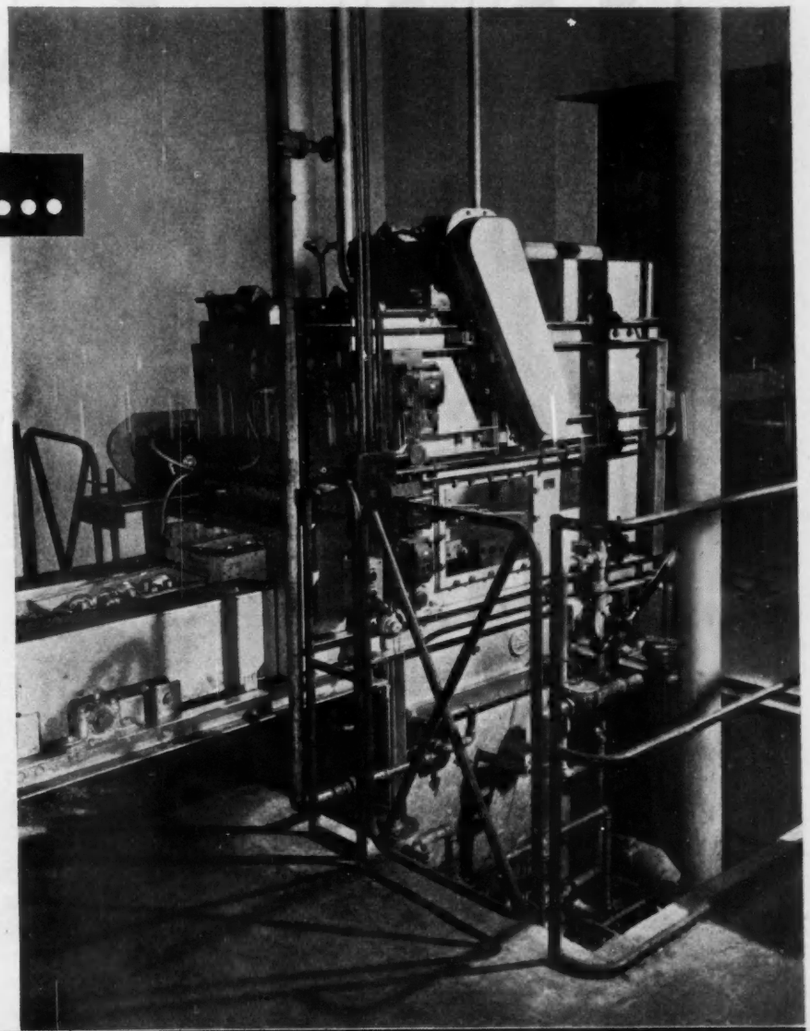

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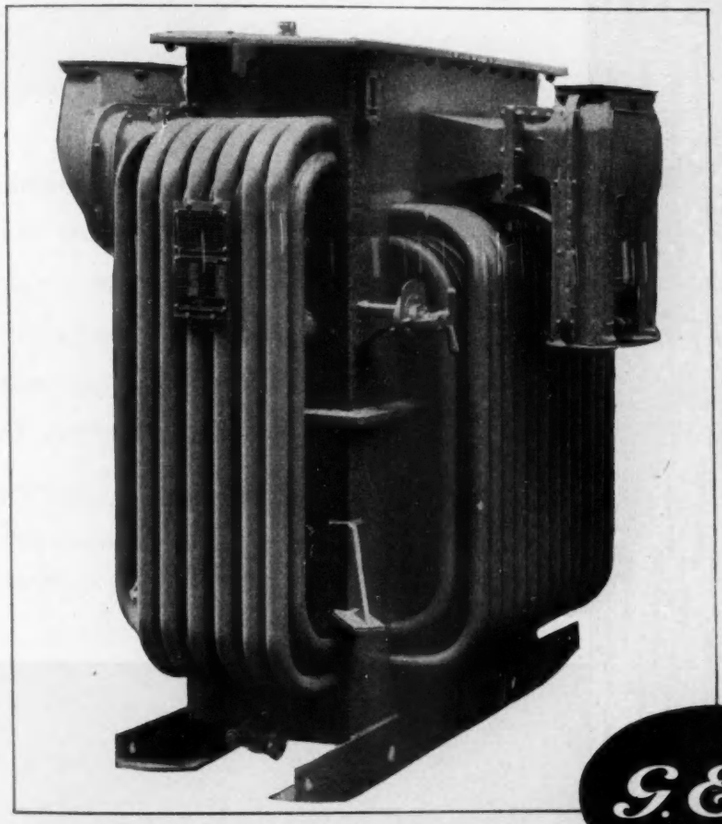

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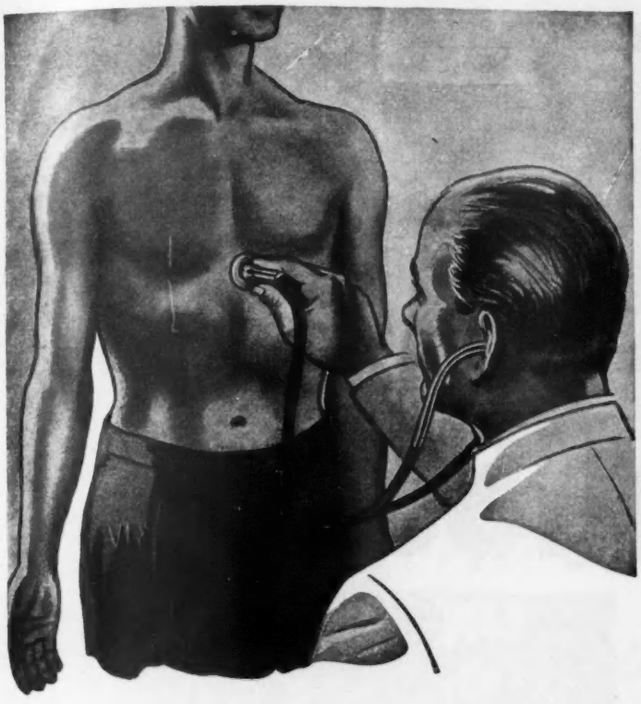

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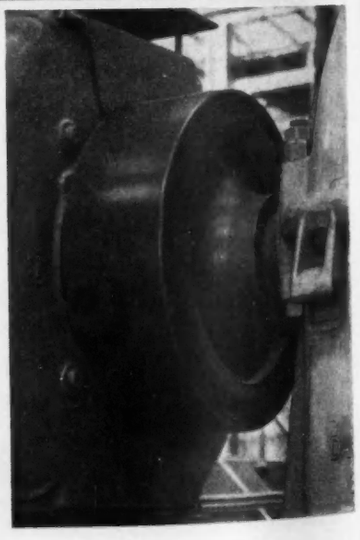

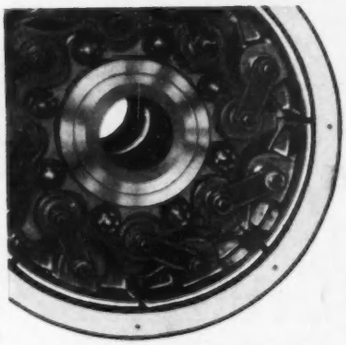

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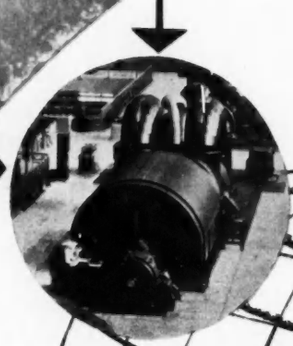

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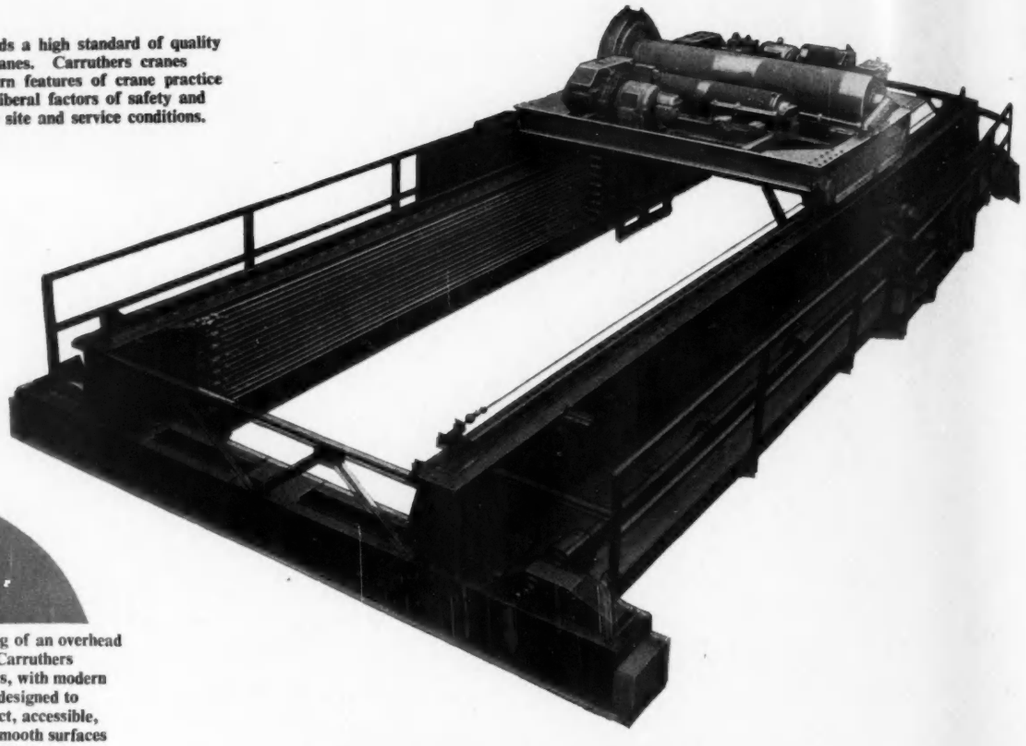

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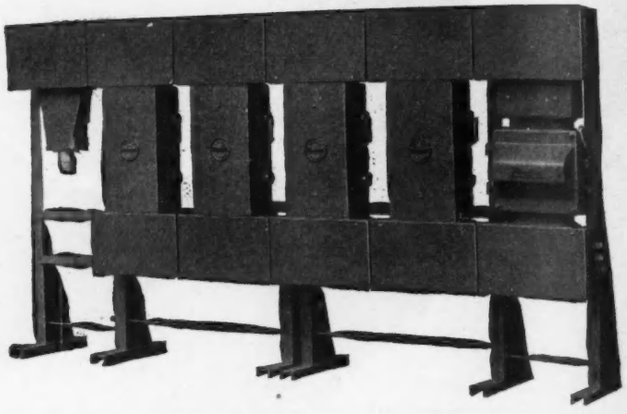

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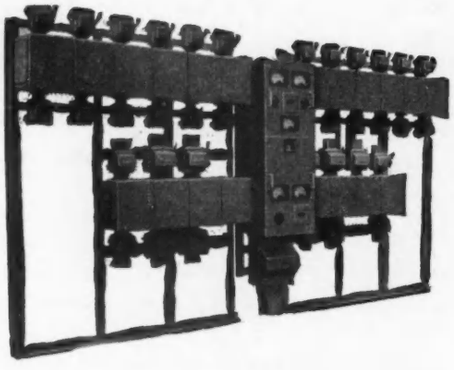

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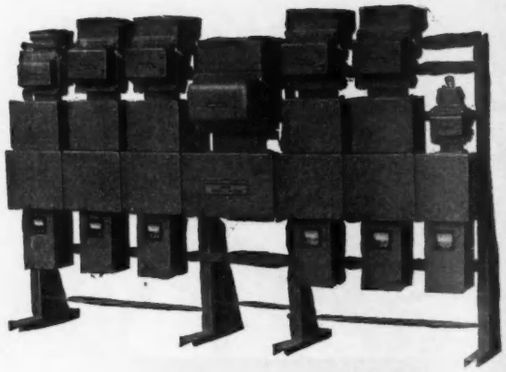


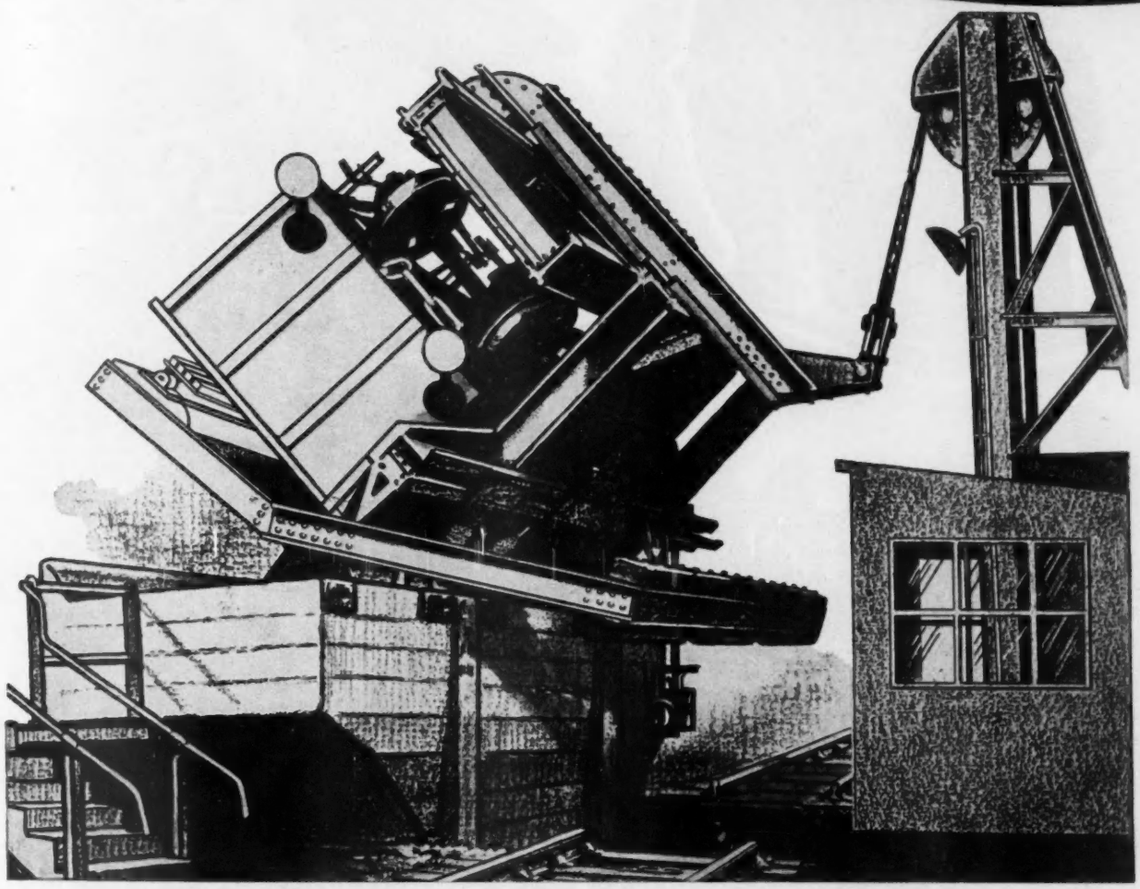
Unit type switchboard supplied to Ericsson Telephones Limited, Beeston, Nottinghamshire.

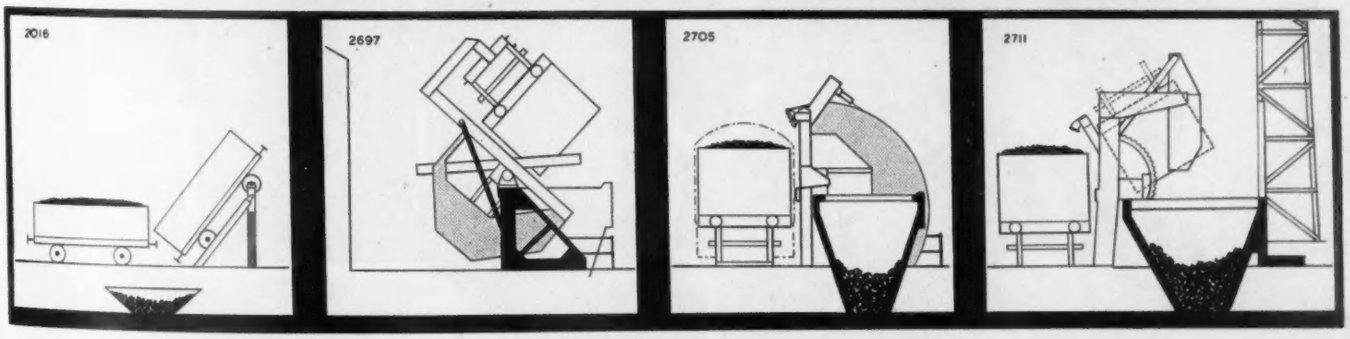
★ *Descriptive literature available on request.*

PARMITER HOPE & SUGDEN LIMITED · MANCHESTER 12

London: 34 Victoria Street, S.W.1. Glasgow: 5, Somerset Place, C.3. Birmingham: 39/41 Carrs Lane, 4

Wagon Tipplers by HENRY LEES & COMPANY LIMITED



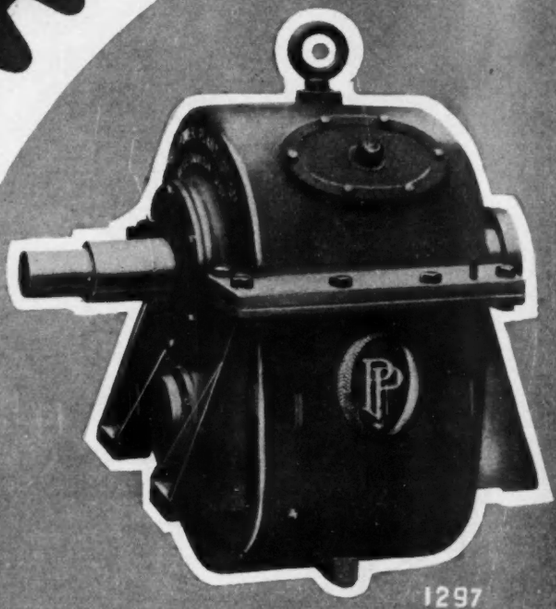


In our range of wagon tipplers we continue to offer an unrivalled choice of machines to suit the varying needs of industry. Many years of experience in producing wagon Tipplers lie behind such new designs as are outlined in figures 2697, 2705 and 2711 above. We should welcome the opportunity to submit up-to-date particulars of suitable machines to meet customers' particular site conditions. All machines comply with the Railway Clearing House requirements.

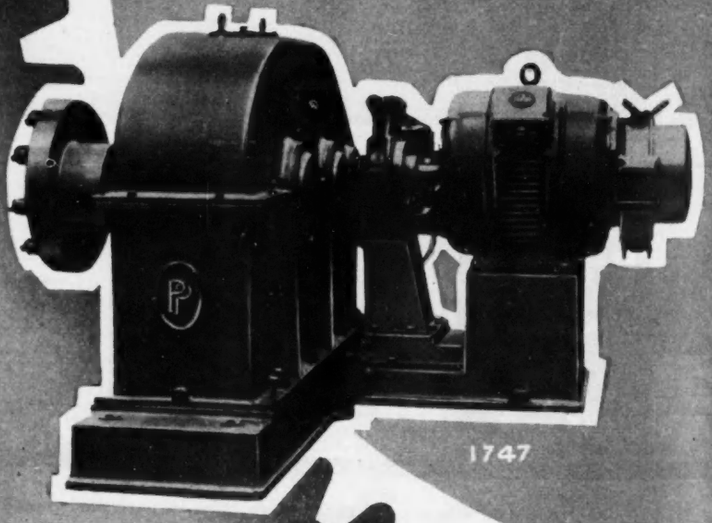
2016 Geared ram type end door discharge tipper.
2697 Rope ram type side discharge tippler.
2705 Rope ring type side discharge tippler.
2711 Geared ring type side discharge tippler.

HENRY LEES & CO. LTD. ENGINEERS & CONTRACTORS, MOTHERWELL, SCOTLAND
PHONE: MOTHERWELL 1818-9 GRAMS "ROLTIP" MOTHERWELL

Ratios up to 50 to 1
Powers from 1H.P. to 4000H.P.



STANDARD GEAR UNITS



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In fact the demand is growing so fast we're just completing large extensions to our Peterborough factory And to make sure our customers get the service we think they deserve, there are Perkins Sales and Service facilities in most countries of the world If you have a power problem, we'll be glad to help you.

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The Diesel Engine with the Clean Exhaust

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78G

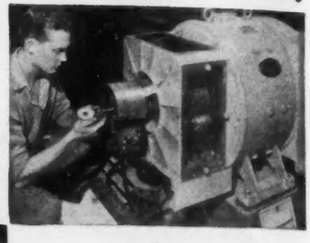
That most versatile Instrument — *the Hand Tachometer*

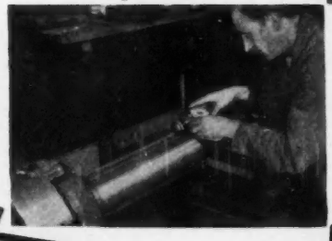
The SMITHS Hand Tachometer is used by such a wide variety of industries and trades and for so many different purposes, that to mention a few applications is but scratching the surface. Its users range from major industries to small workshops and include manufacturers of hair nets, toffee, umbrellas, slippers and—quite likely, candlestickmakers.

Briefly, Smiths Hand Tachometers provide a ready and accurate check on rotational and surface speeds. Their use is a safeguard against excessive wear of plant and uneconomical operation.

The Hand Tachometer serves Industry

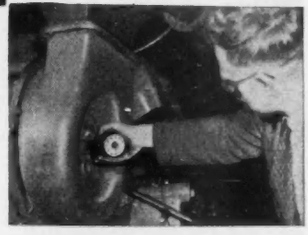
A Hand Tachometer is shown here at a G.E.C. factory, measuring rotational speed during the normal testing of a 10 kW, 125 volt exciter.





In this instance, the English Steel Corporation Ltd. are using a Hand Tachometer to indicate the surface speed of a test bar during a turning tool investigation.

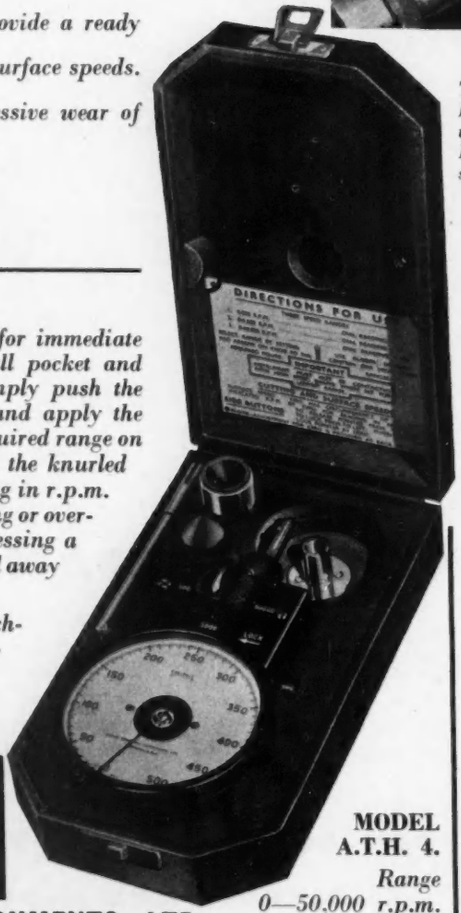
This picture shows a Hand Tachometer in use by 'English Electric' for rating superchargers.



Using the Hand Tachometer

The instrument is always ready for immediate use. It can be slipped into an overall pocket and carried as easily as a slide-rule. Simply push the appropriate attachment on to spindle and apply the instrument to the belt or shaft. The required range on each Tachometer is selected by turning the knurled knob and the dial gives the correct reading in r.p.m. or f.p.m. Under conditions of bad lighting or overhang, the pointer can be locked by depressing a button. The reading can then be observed away from the take-off point.

EACH SET COMPRISES Hand Tachometer, male rubber centre, female rubber centre, three-inch extension piece, disc for surface and cutting speeds (for reading in either feet or metres)



MODEL A.T.H. 4.
Range 0—50,000 r.p.m.

This versatile instrument is also used for

retiming diesels • press work • checking cutting speeds (especially during piece-working) • belt speeds • time and motion study • and for a thousand other purposes.

* *Accuracy ½% of the measured reading*
* *For either direction of rotation*
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MODEL A.T.H. 6.
Range 0—10,000 r.p.m.

MODEL A.T.H.7.
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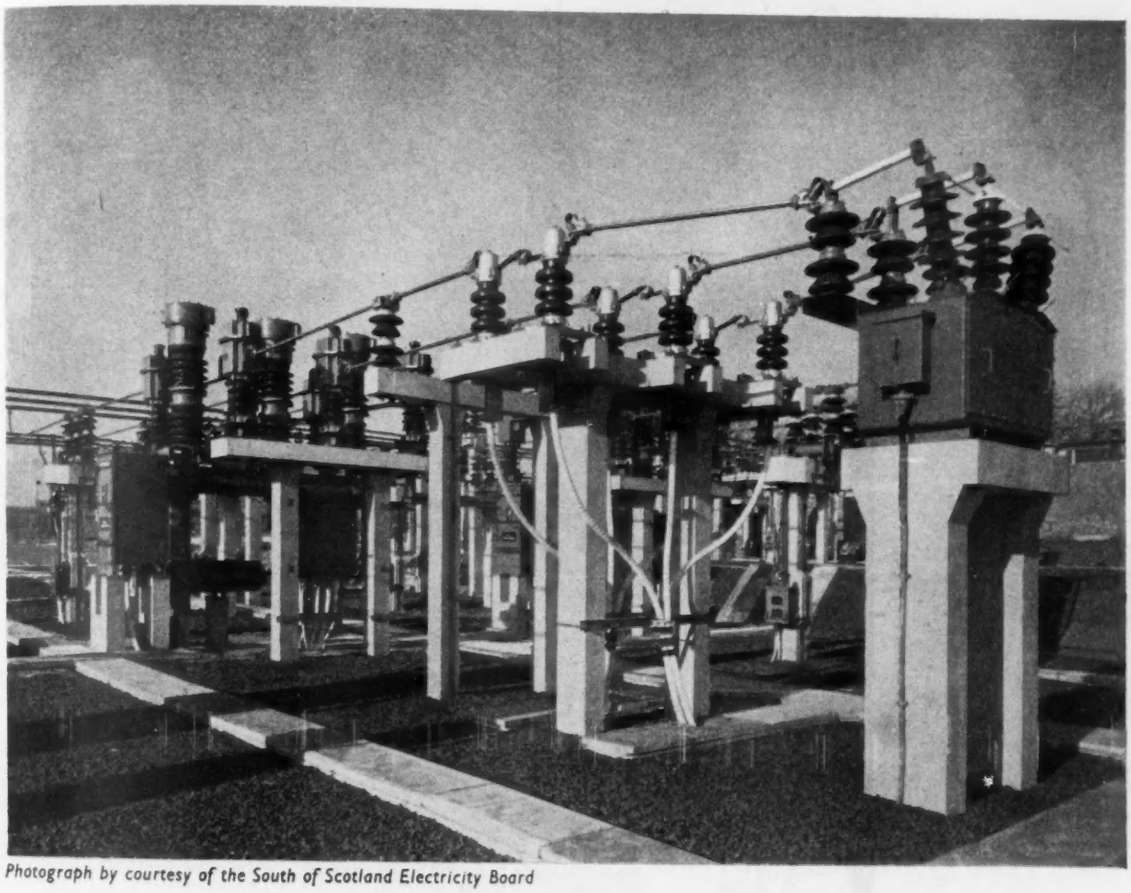


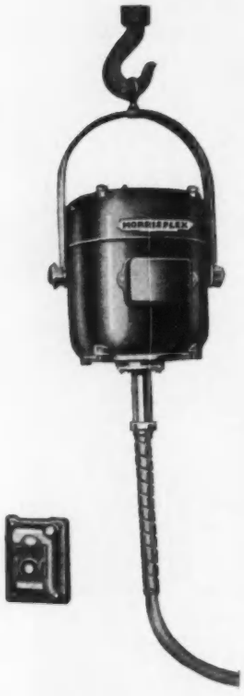
Photograph by courtesy of the South of Scotland Electricity Board

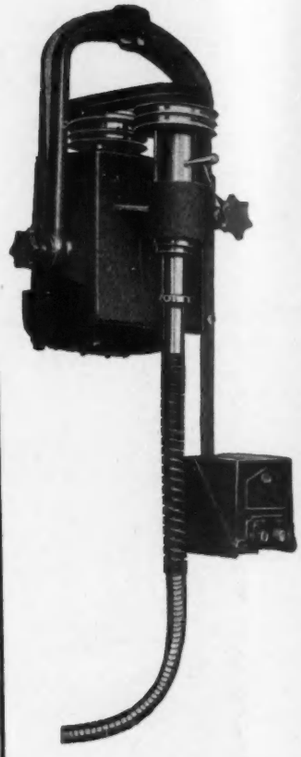
System reinforcement in Ayrshire

Reyrolle 33-kV small-oil-volume circuit-breakers now in commission at Coylton 132/33-kV sub-station

Reyrolle

A. REYROLLE & COMPANY LIMITED HEBBURN, COUNTY DURHAM, ENGLAND





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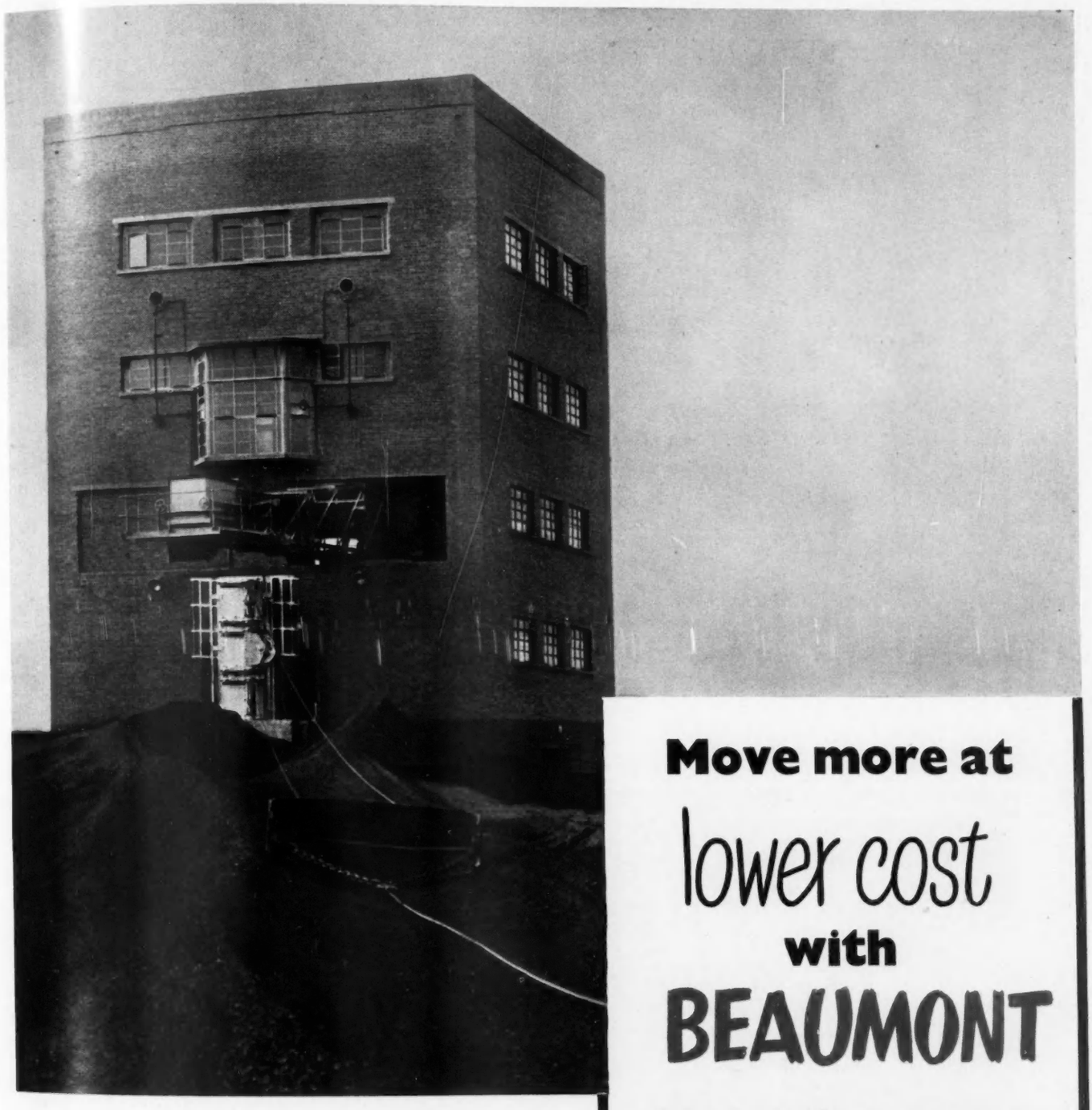

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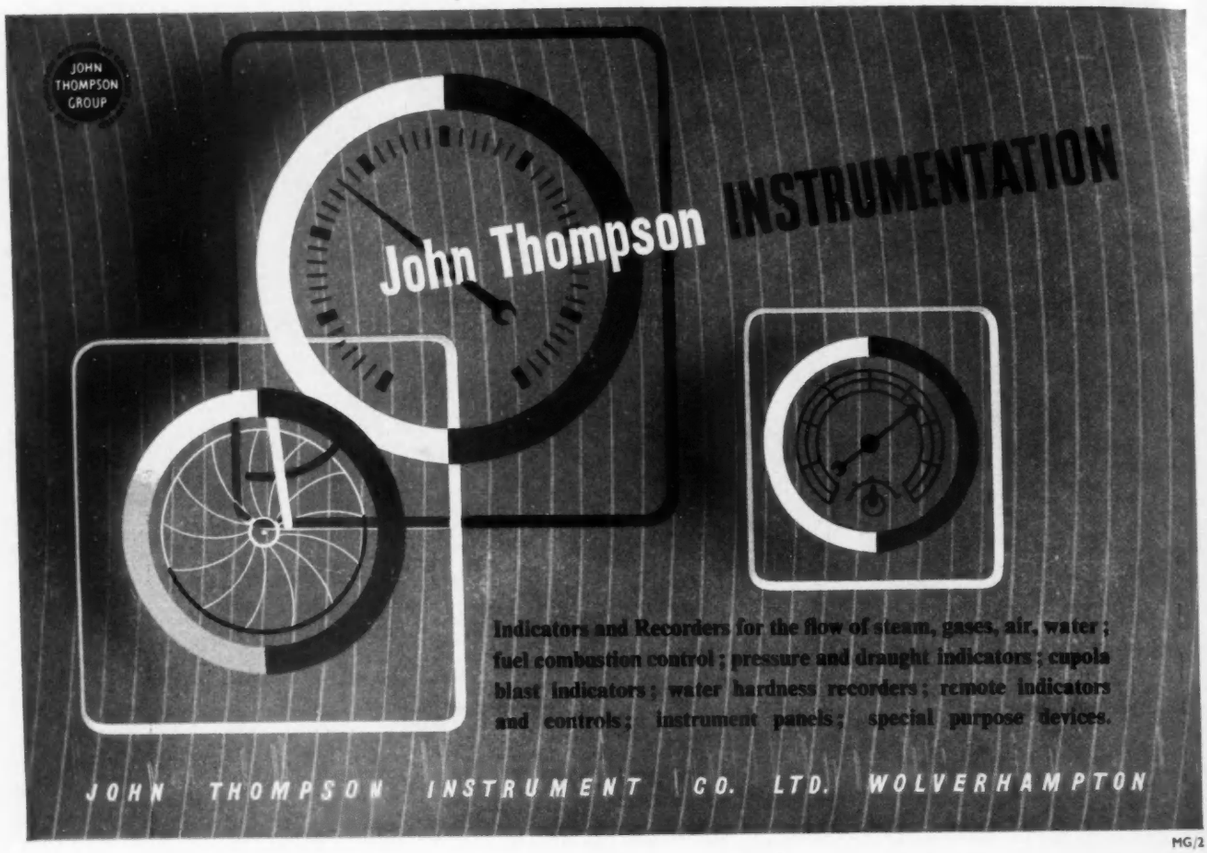
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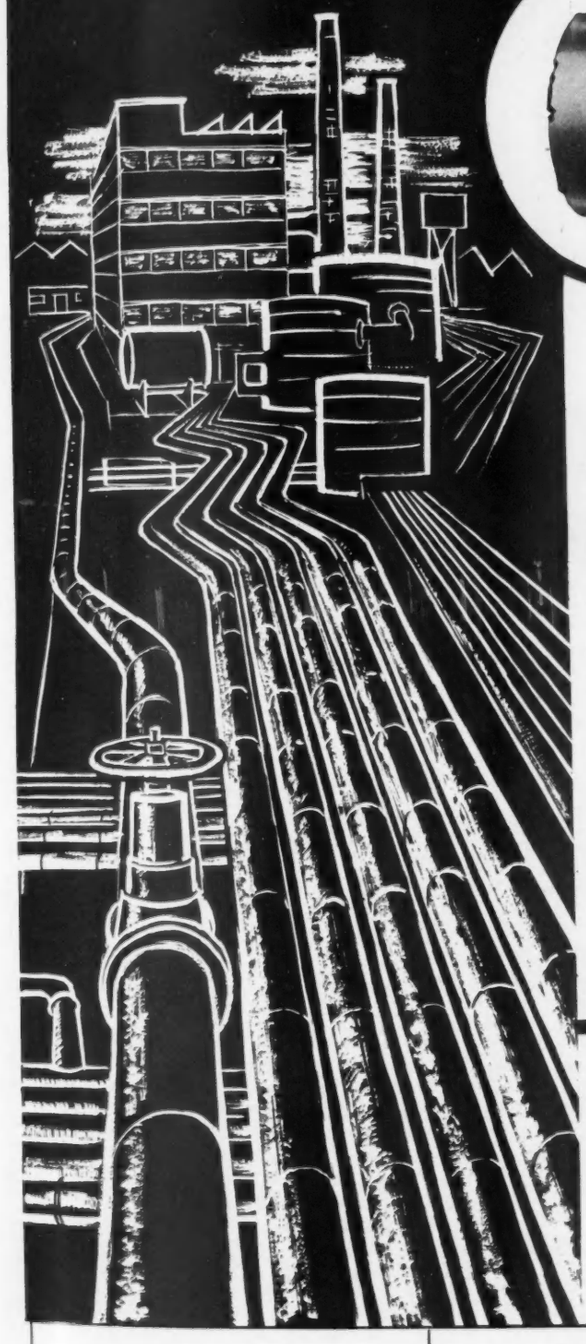

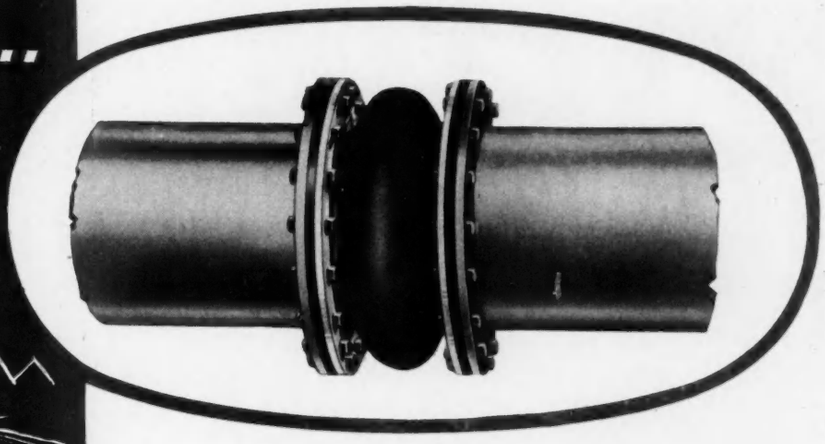

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They are available in a range of sizes from 2-60 ins. diameter for use with British and American standard pipework. Flexible faring pieces and fireguards are also available.

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- **Many other chemicals.**
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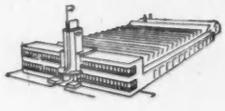

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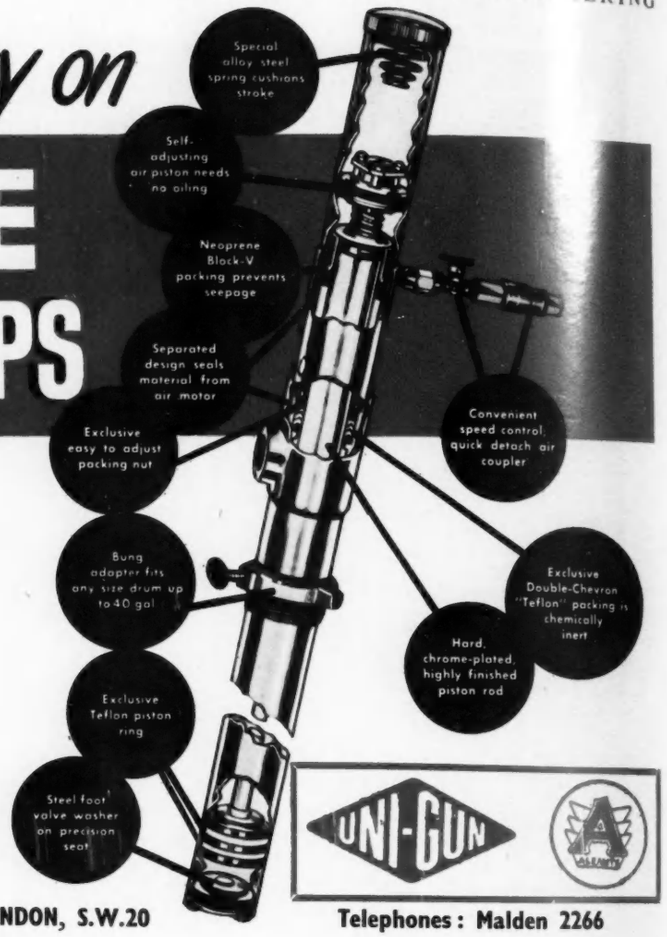
ALEMITE TRANSFER PUMPS


Special alloy steel spring cushions stroke
Self-adjusting air piston needs no oiling
Neoprene Block-V packing prevents seepage
Separated design seals material from air motor
Exclusive easy to adjust packing nut
Convenient speed control; quick detach air coupler
Bung adapter fits any size drum up to 40 gal
Exclusive Double-Chevron "Teflon" packing is chemically inert
Hard, chrome-plated, highly finished piston rod
Exclusive Teflon piston ring
Steel foot valve washer on precision seat

MODEL 7216A—Air-Operated " Gusher " Pump. High speed, fully controlled delivery of any fluid or semi-solid material direct from original drum. Handles pressure gun grease, oil, shellac, cutting oils, alcohol, etc. Delivers 12 gallons of SAE 10 oil in just 60 seconds! Light weight—only 15½ lbs.—makes it easy to change from one drum to another. Fits 2in. B.S.P. bung.

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Manufactured by UNI-GUN LUBRICATING EQUIPMENT LTD. LONDON, S.W.20

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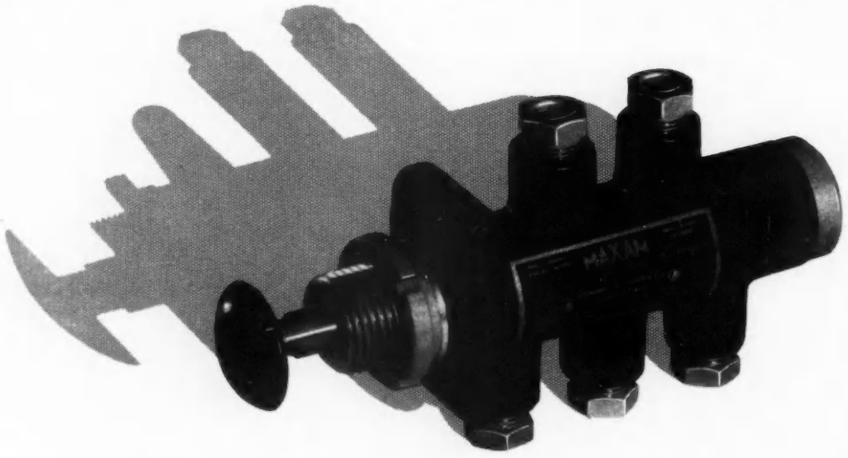

Fine figure of a valve

This is a Maxam hand-operated air valve—compact, well-designed and precision-made at the famous Climax works. With 150 other valves (cam-or solenoid-operated, 3-way, 4-way etc.), and other Maxam equipment, it is helping to keep production up and costs down all over the world (and for more than 3,000 customers, and many more factories, to date in Britain alone). Maxam can help **you** too—may our technical staff discuss **your** problems?

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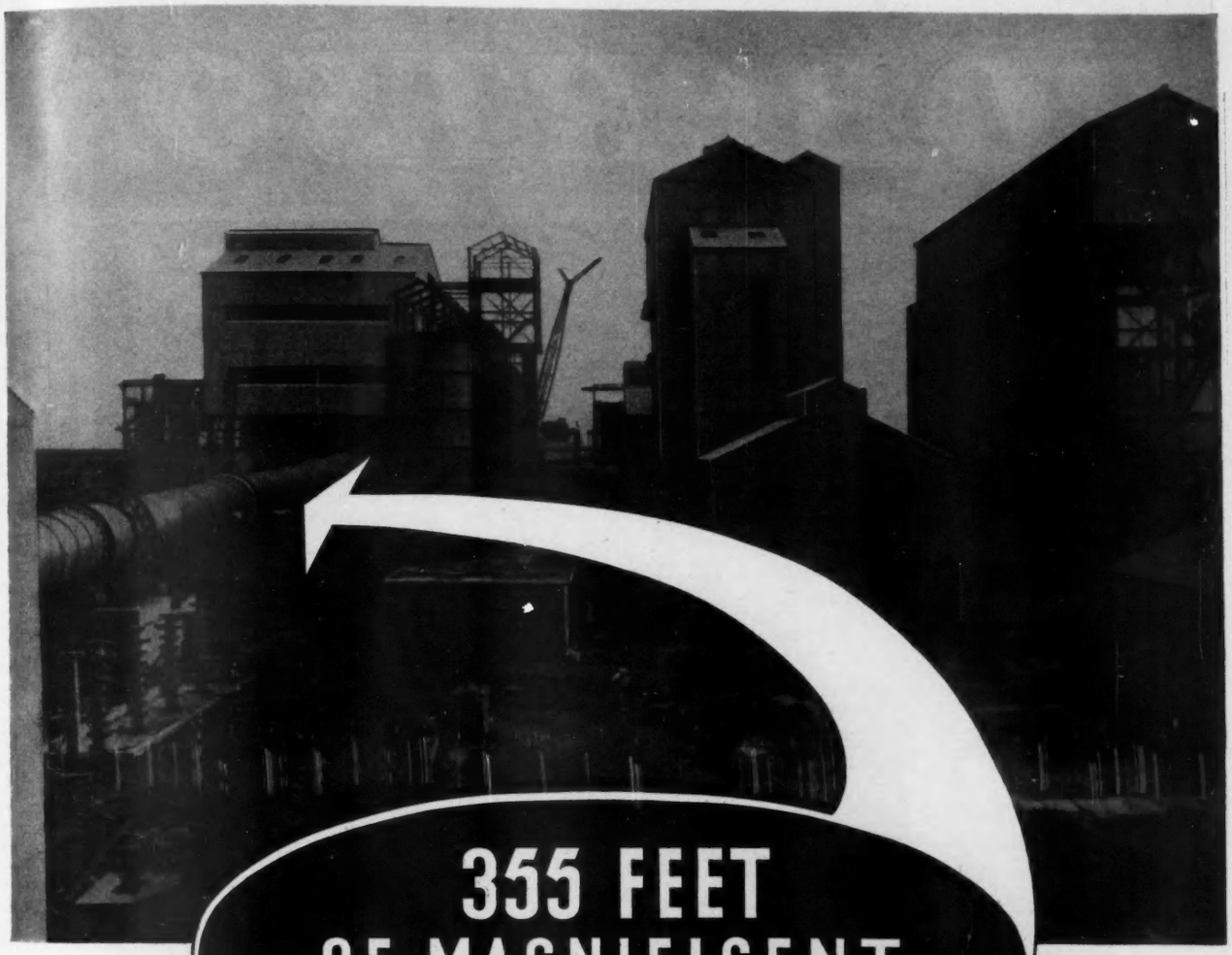

355 FEET OF MAGNIFICENT WORKMANSHIP

The photograph shows one of the two 355ft. Edgar Allen rotary kilns recently supplied, with much other equipment, to the United Sulphuric Acid Plant at Widnes. The kilns, fired by pulverised coal, produce a clinker composed of alumino-ferrate and silicates of calcium. The kiln gases, after being cooled and cleaned, are converted into sulphuric acid.

This is but one of the Edgar Allen contributions to the world's chemical processing. Write for literature. We manufacture rotary kilns, industrial drying plant, tube mills, ball mills, crushers, pulverisers, cement and lime-making plant, etc.

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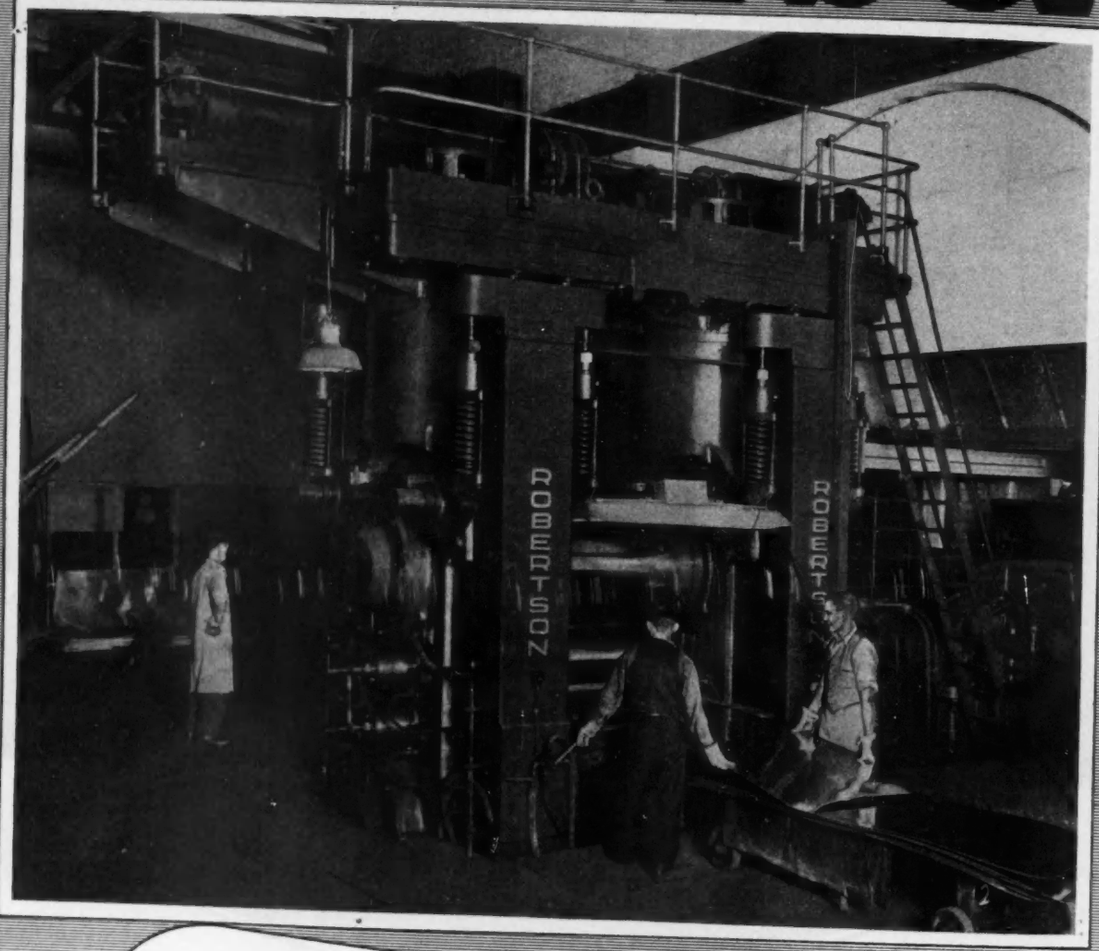

Large sheet mills such as this are typical of the range of Robertson equipment. Robertson's Rolling Mills lead the field in design, workmanship and mechanical efficiency and their range of auxiliary equipment covers every modern need.

The above photograph illustrates a Robertson Four-High Sheet Mill installed at Messrs. Samuel Osborn & Co., Ltd., Sheffield.

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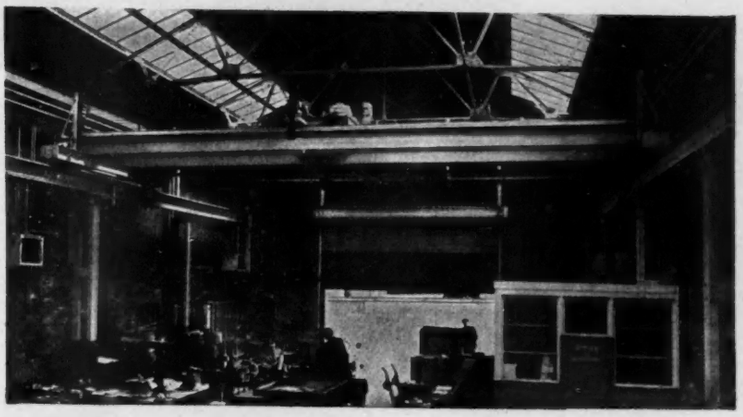

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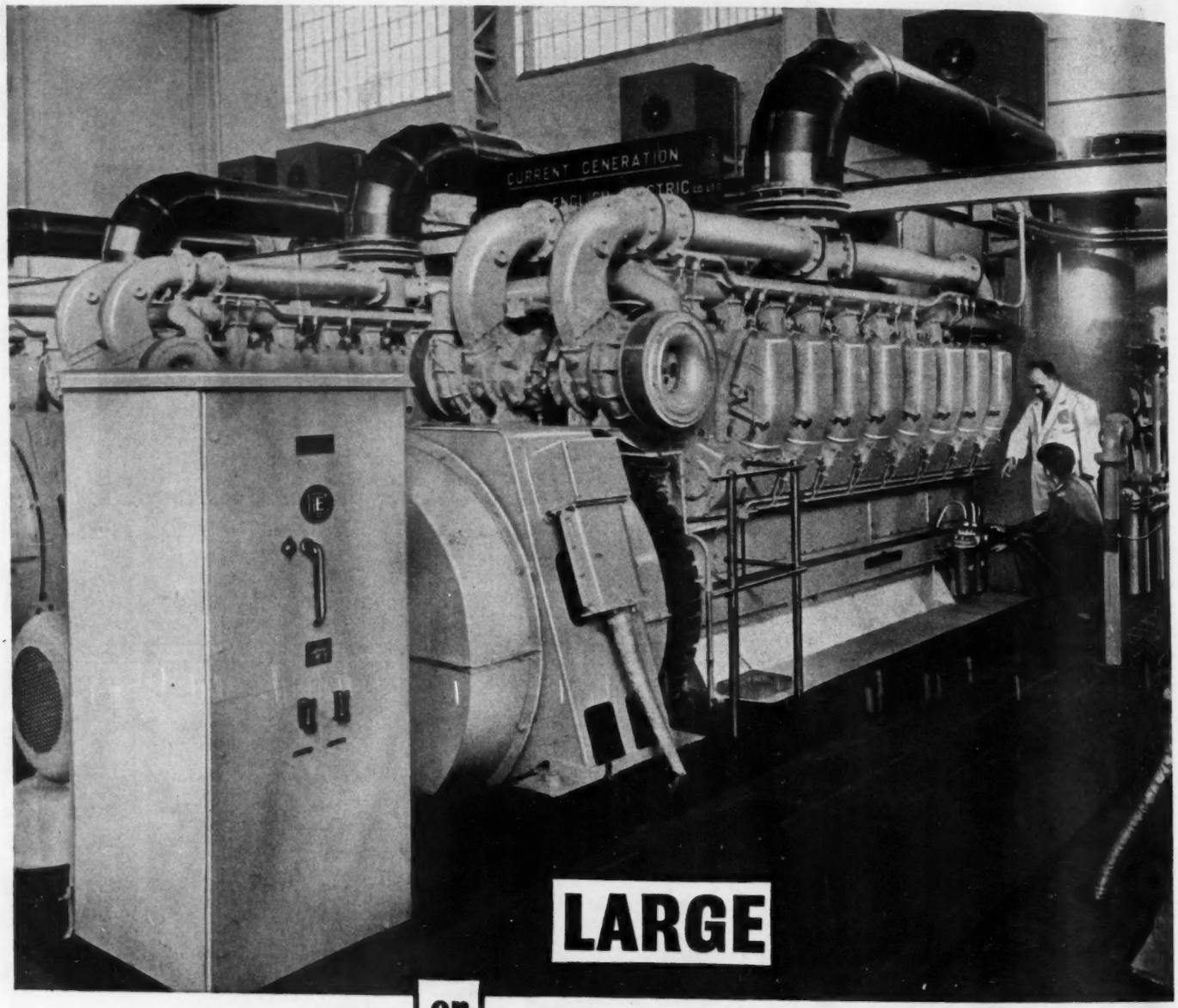

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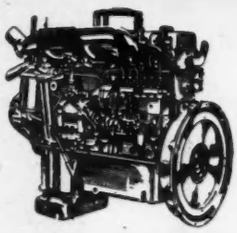

Perkins P6 Engine

Three 1,000 kW. 'English Electric' type 16SV diesel-alternator sets. Photo by courtesy of Leyland Motors Limited.

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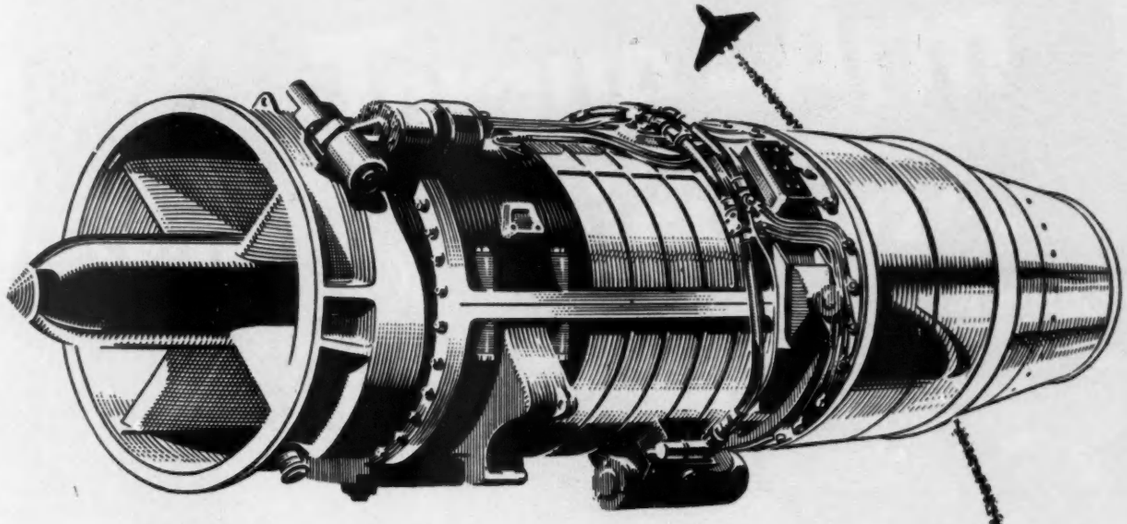

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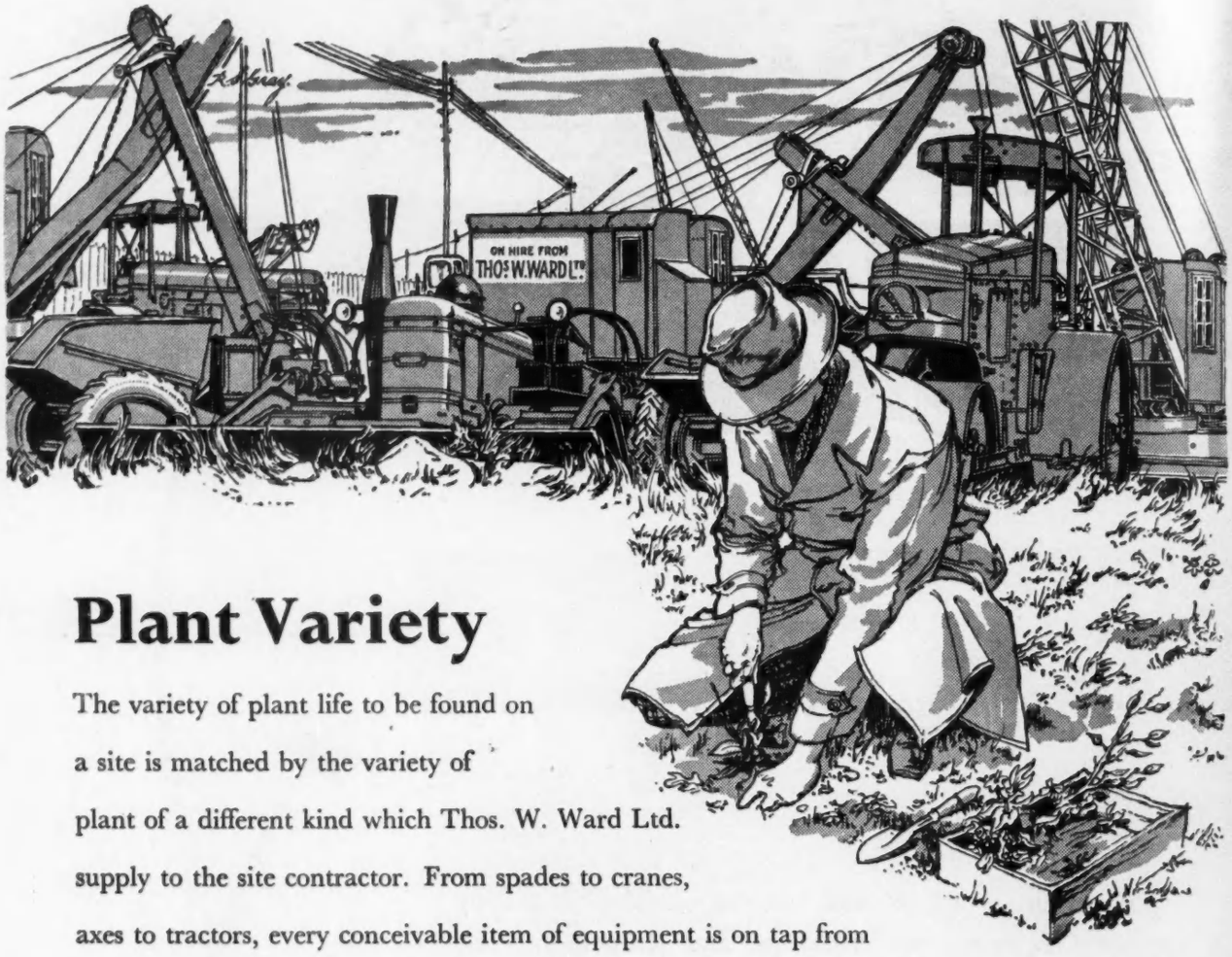

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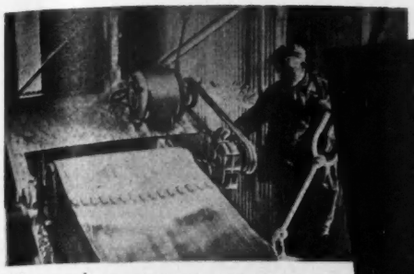
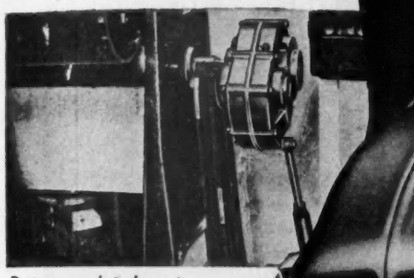
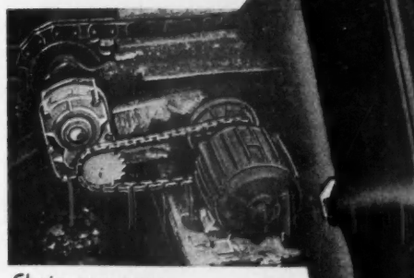


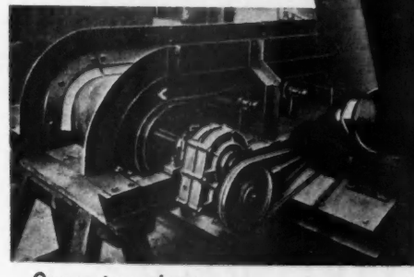
Heavy duty quarry conveyor.



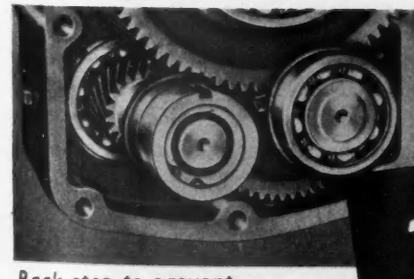
Paint and ink mixer.



Chain conveyor.



Quarrying plant.



Back stop to prevent reversal of direction.

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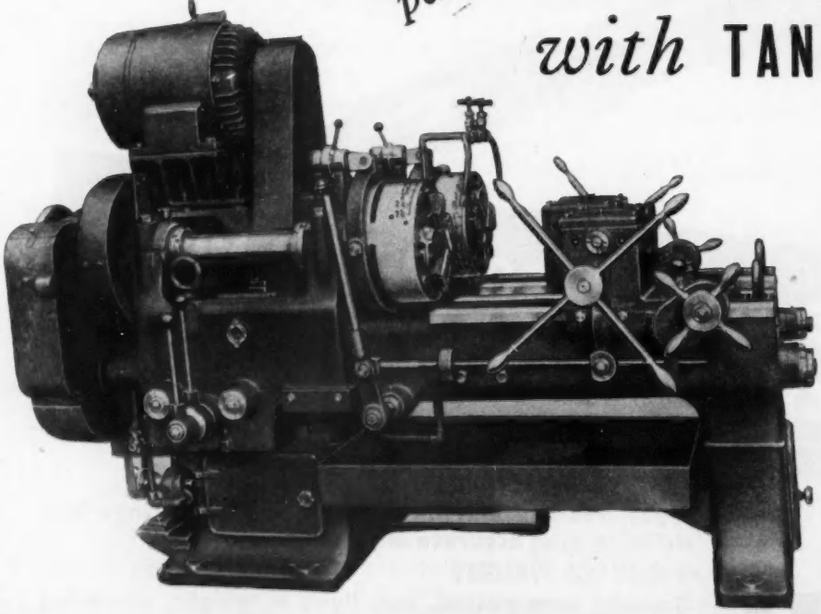
HEAP'S *patent* **SCREWING MACHINES** *with* **TANGENTIAL DIES ★**



The illustration shows our 2½ in. Double Head Bolt Screwing and Nut Tapping Machine which will cut either right or left hand threads (or both at the same time). It is fitted with our patent Tangential Die Heads, which open automatically when any predetermined length has been screwed, and with two Leading Screws extending the full length of the bed, which ensure absolute accuracy of pitch. 16 in. can be screwed at one setting.

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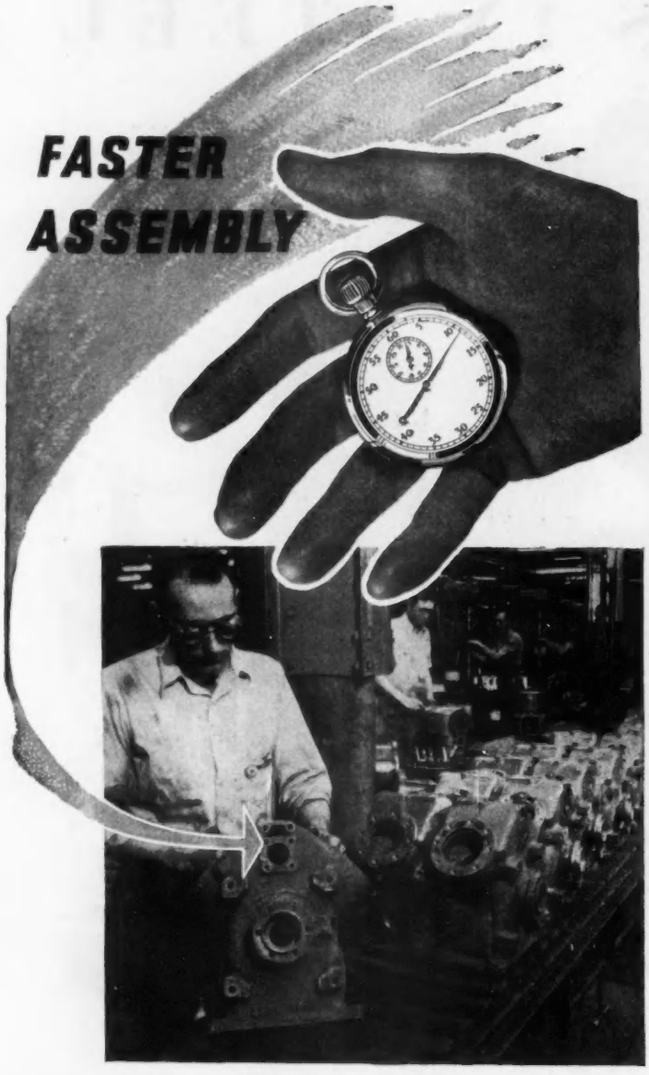

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SCREW THREAD INSERTS

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No fractional gains either; substantially faster and surer assembly is a certainty and here's why:—

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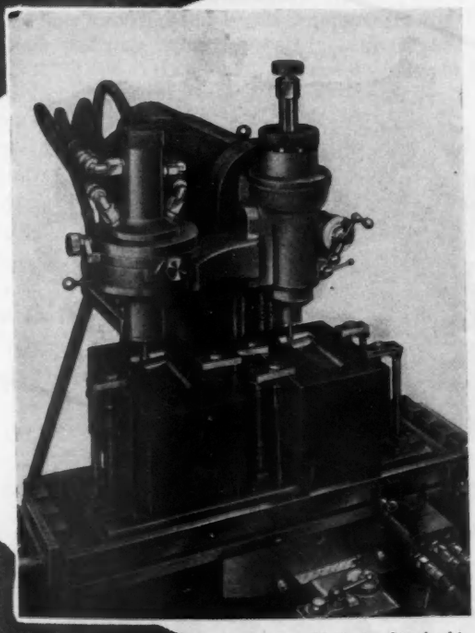

Block size 8 in. by 6 in. by 6 in. in Firth-Brown Steel.

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Diesinking with Hayes

"TRACEMASTER"

Copy Milling Machine

The photograph illustrates an actual and typical diesinking operation on drop forging blocks showing machining of a gas turbine blade die under FULLY AUTOMATIC control.

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FARRAR BOILERS

TRADE MARK

OTHER TYPES OF BOILERS MADE INCLUDE:-
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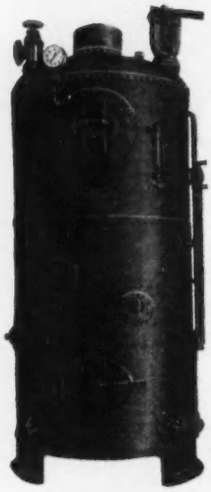
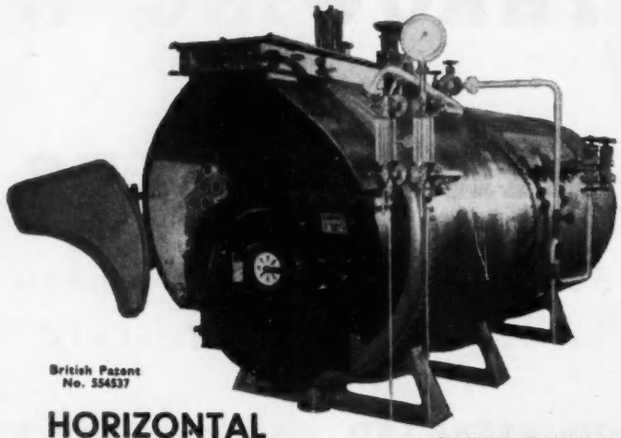
RAISE STEAM WITH A "FARRAR"

FARRAR CROSS-TUBE VERTICAL BOILER



This simply designed, robust boiler is made in several sizes ranging from 5' 0" high x 2' 3" diam. to 14' 0" high x 6' 6" diam.

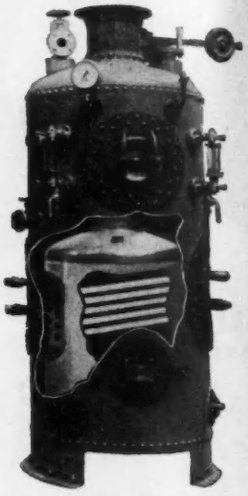


British Patent No. 554537

HORIZONTAL "FARRATUBE" BOILER

EVAPORATIVE CAPACITY FROM 1200 LB. TO 8000 LB. WATER PER HOUR

"FARRATUBE" VERTICAL MULTI-TUBULAR BOILER



Evaporative Capacity from 850 lb. to 3500 lb. water per hour.
British Patent No. 642266.

THE FARRAR BOILERWORKS LTD. NEWARK (Notts) ENGLAND

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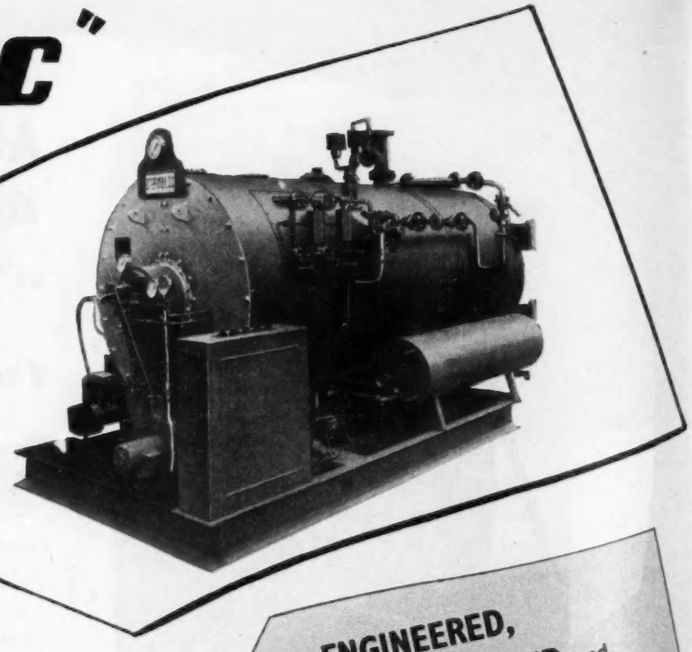

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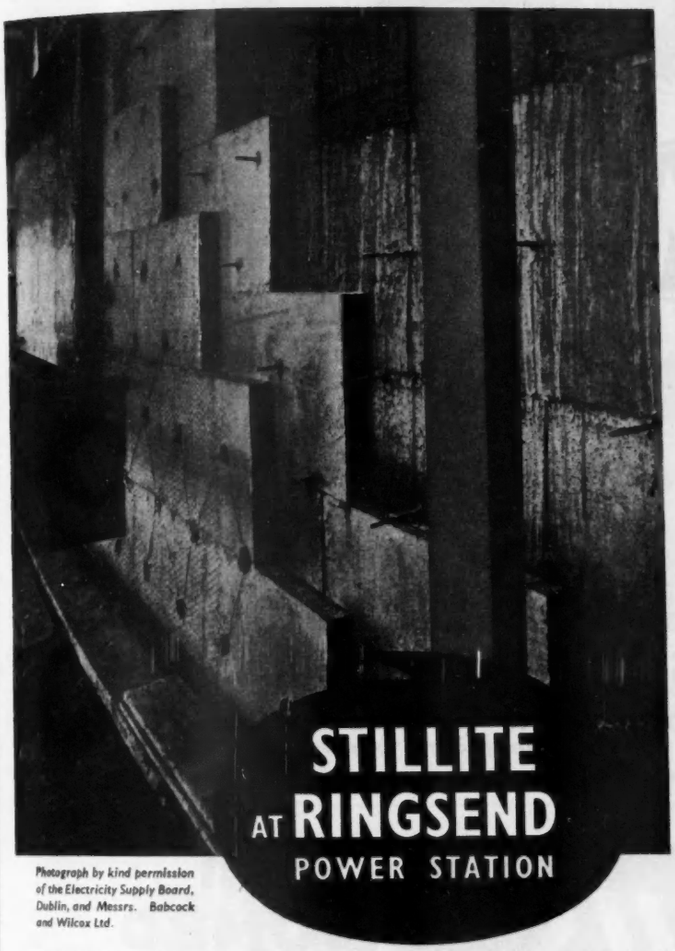
THERBLOC *proves itself*



Photograph by kind permission of the Electricity Supply Board, Dublin, and Messrs. Babcock and Wilcox Ltd.

THERBLOC mineral fibre insulating slab is rapidly replacing conventional backings to refractory materials in a wide variety of industries. The photograph shows STILLITE THERBLOC applied in two staggered layers to the outer surface of the castable refractory and held by pins secured to the tubes.

THERBLOC is one of the STILLITE range of mineral fibre insulants, and has these advantages:—

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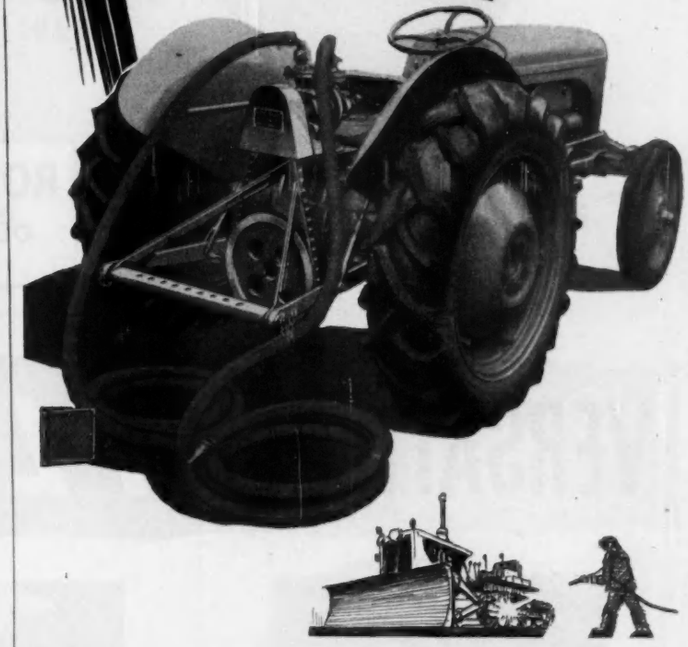

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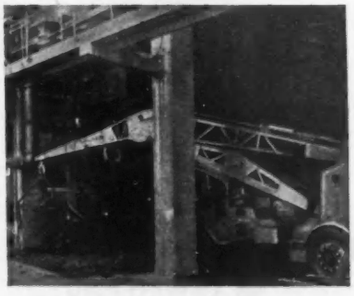

The 4-ton Jumbo Crane lifting a skip of ashes in the 25 cwt. position at Fulham Power Station. Headroom is only 11ft. 2in., so the jib extension, and not the main jib, is being used with unimpaired efficiency.

The Jumbo Junior lifting a railway truck chassis weighing approximately 30 cwt. at Associated Portland Cement Manufacturers, Greenhithe.

Jumbo Mark II 3-ton crane is depositing a load from the grab into a truck for Messrs. J. Taylor & Sons Ltd., Slough.

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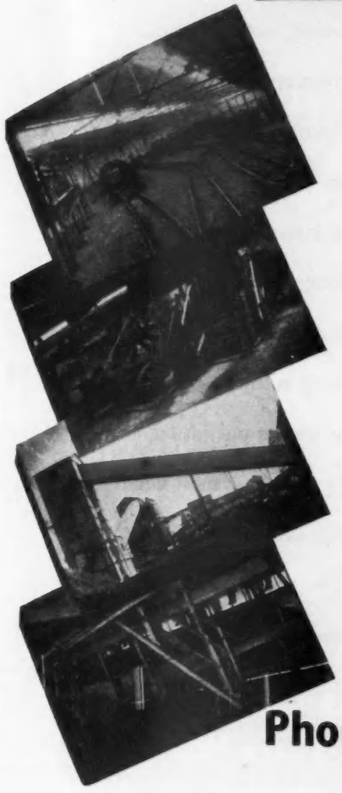

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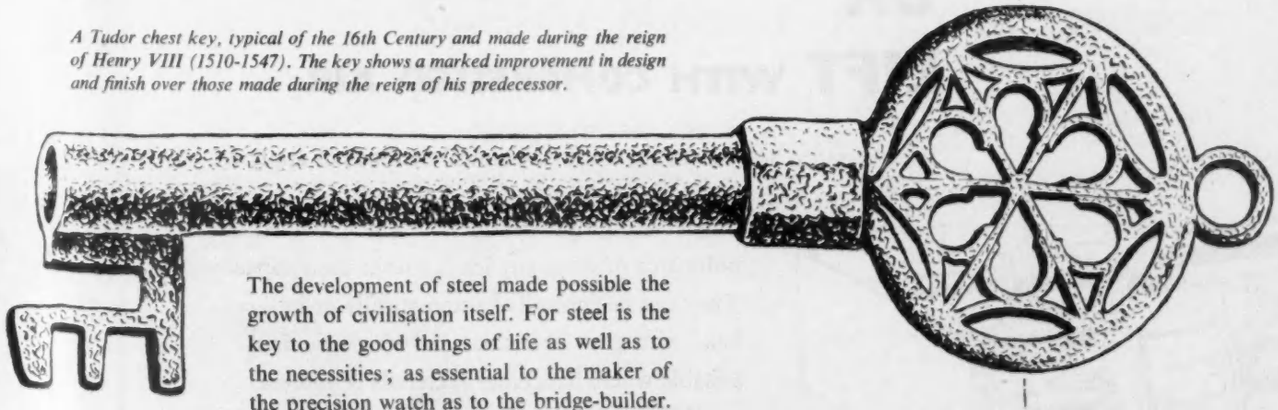

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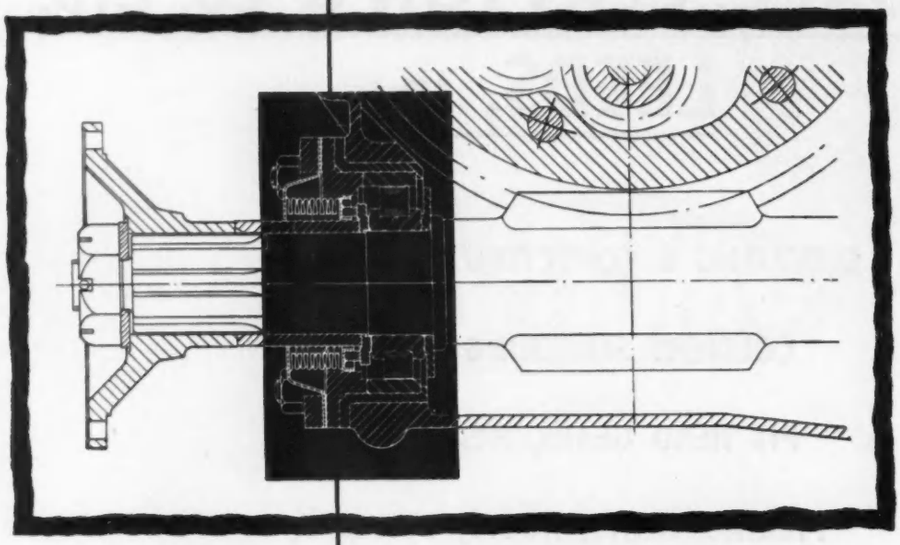

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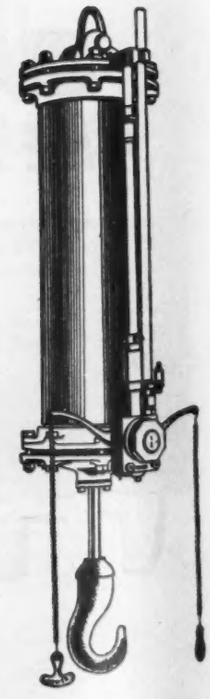

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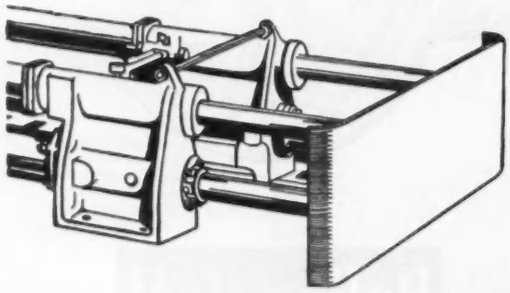

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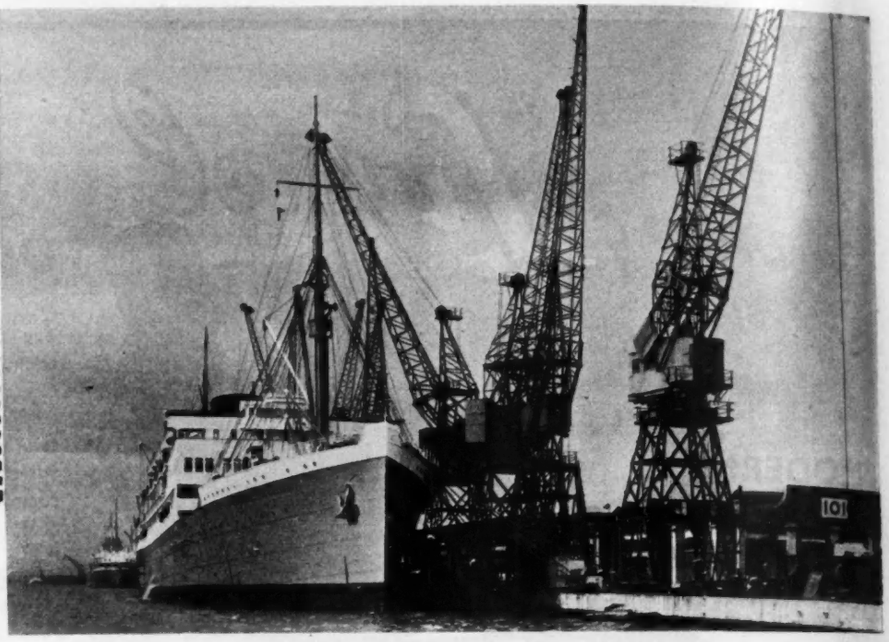

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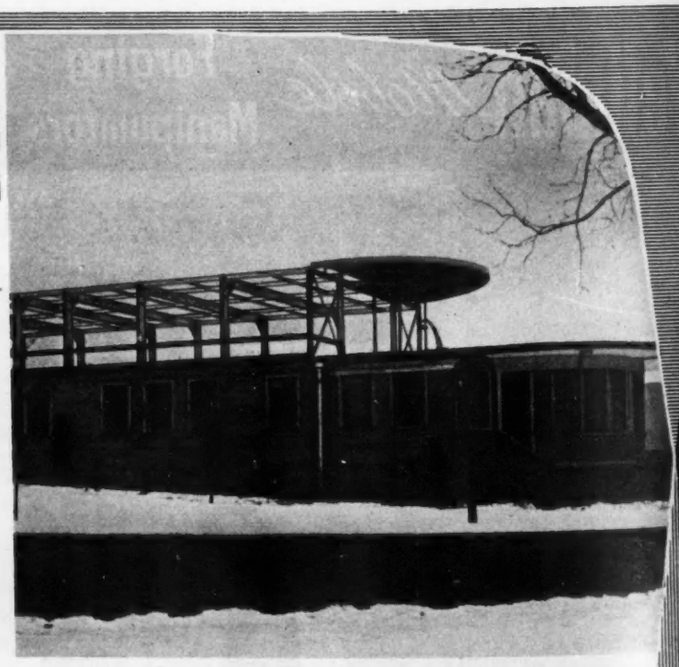

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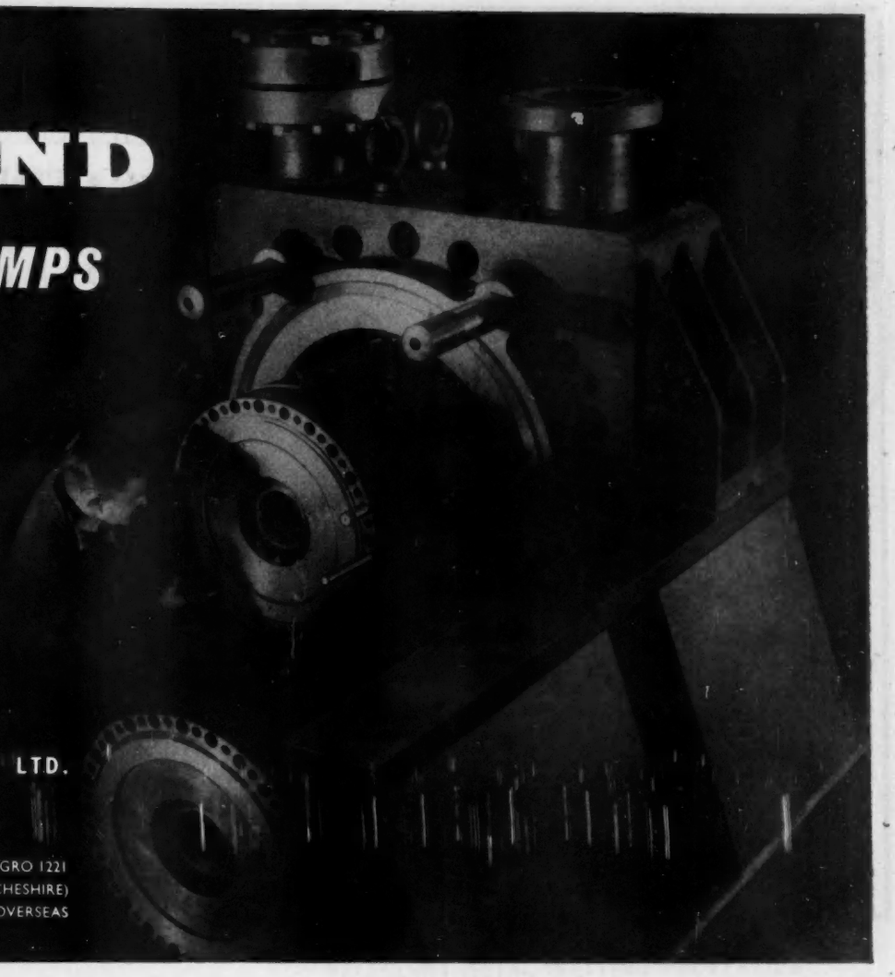

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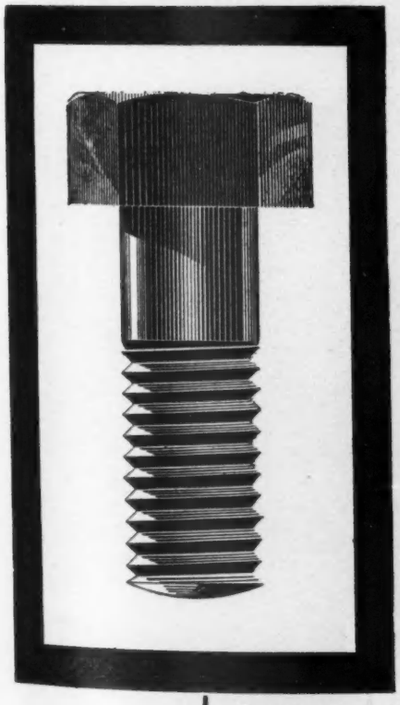

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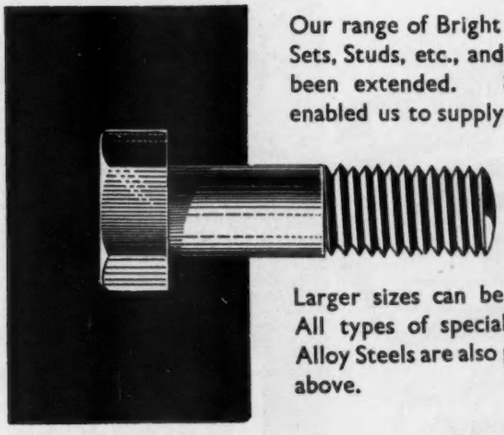
Marwin

BOLTS



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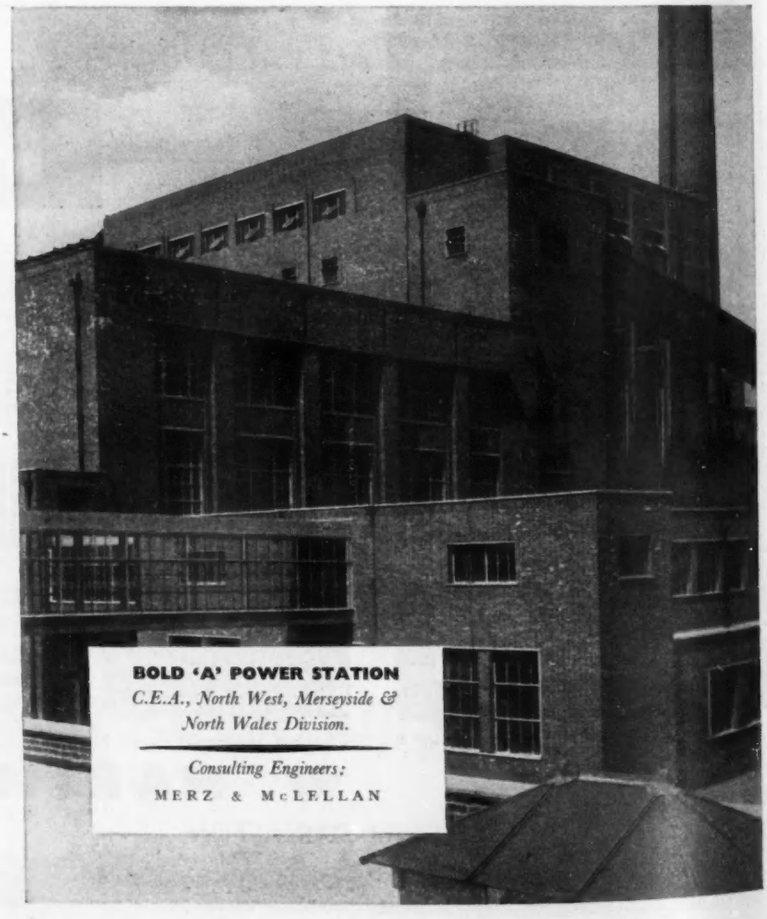

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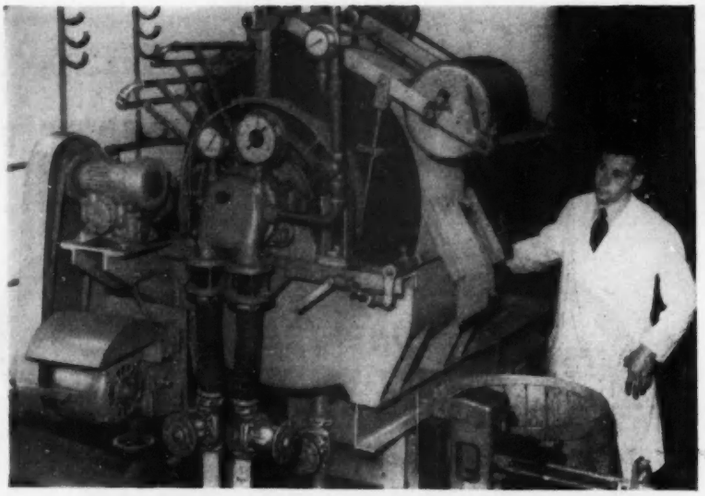

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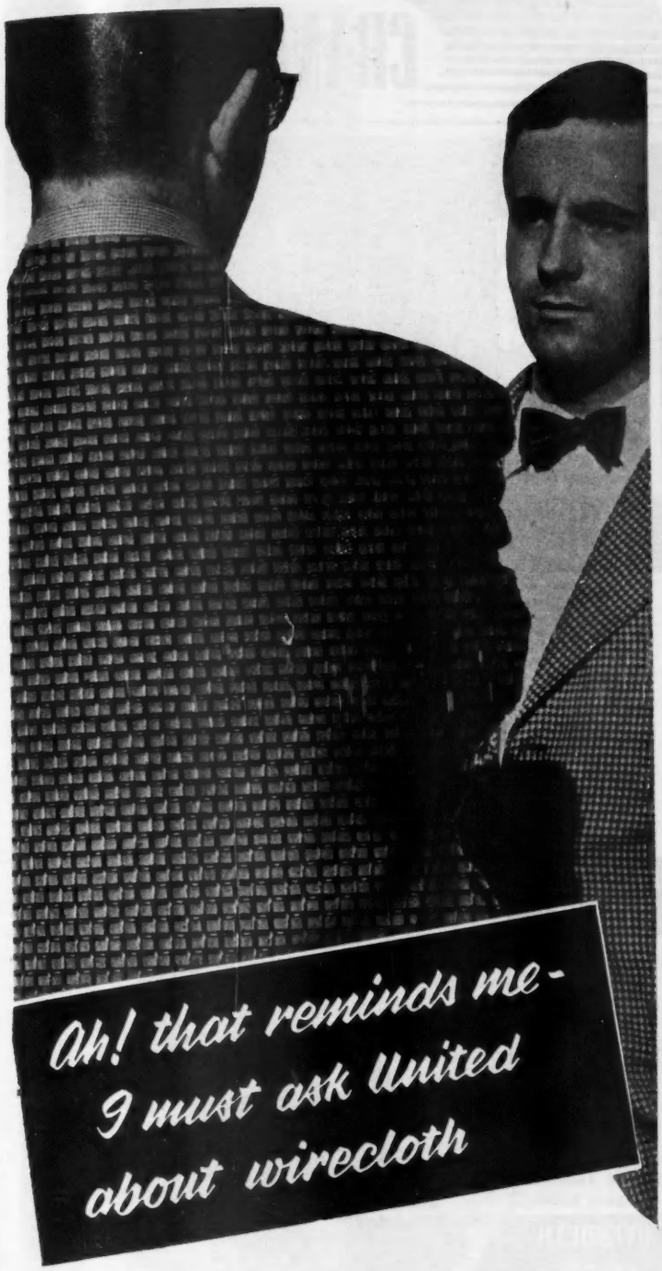

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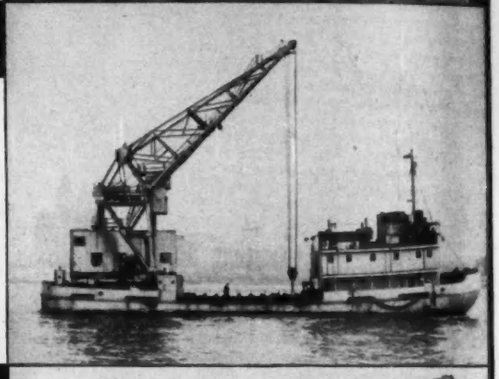

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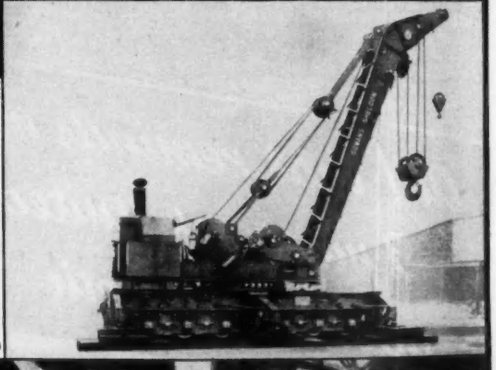

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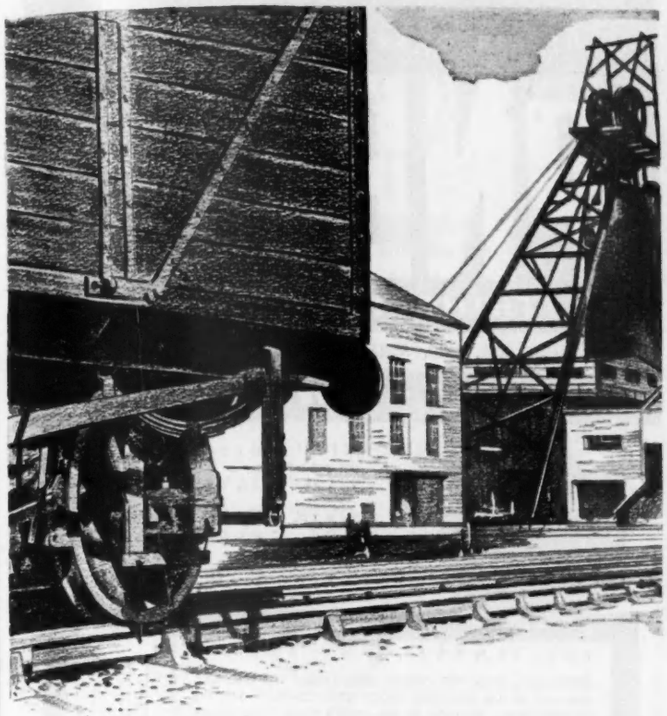

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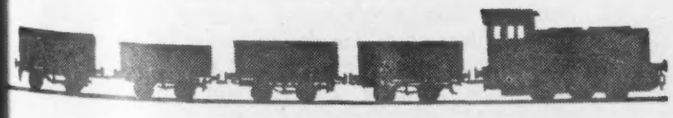

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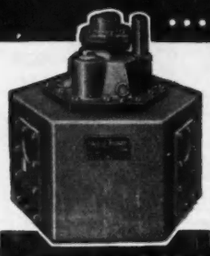

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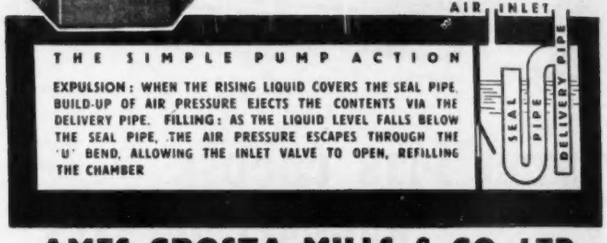

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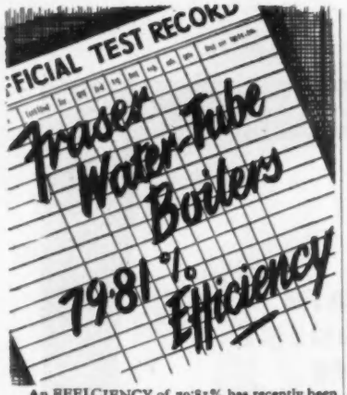

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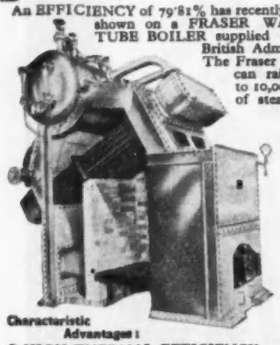

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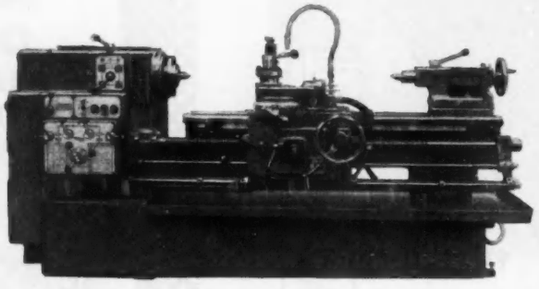

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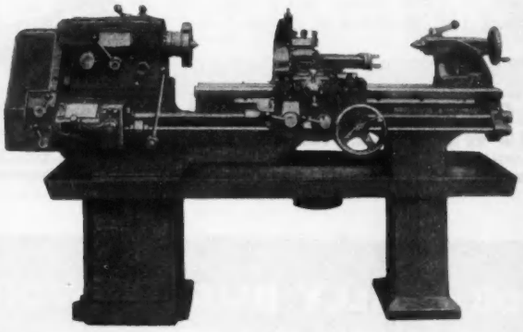

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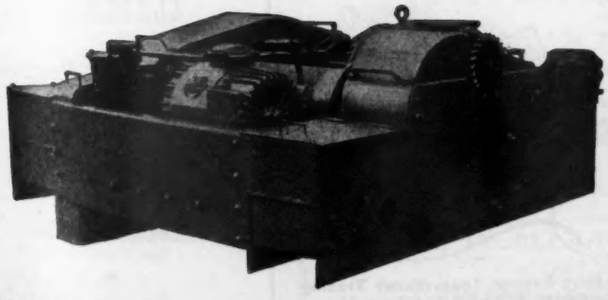

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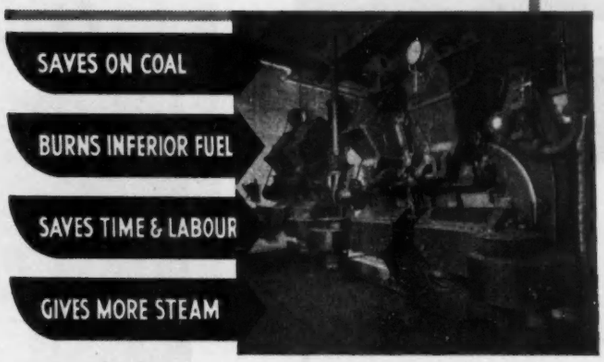

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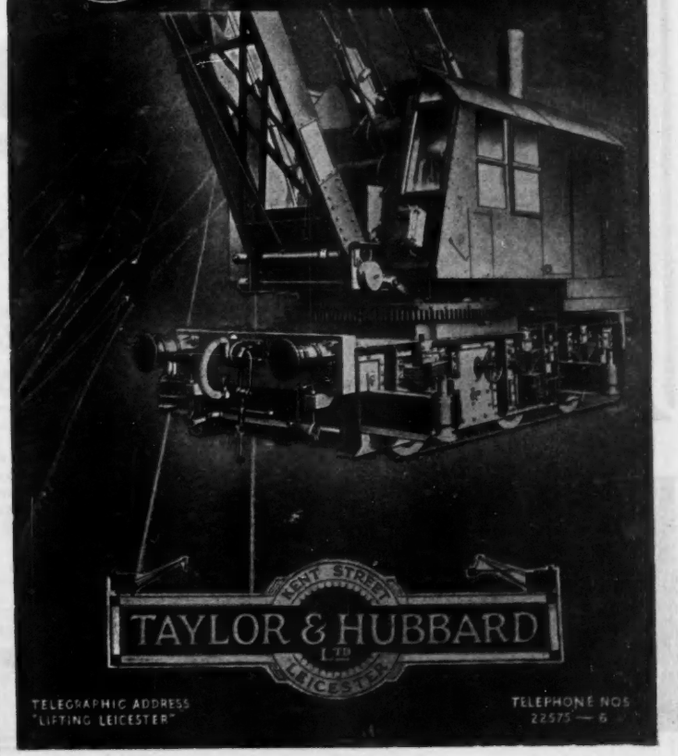

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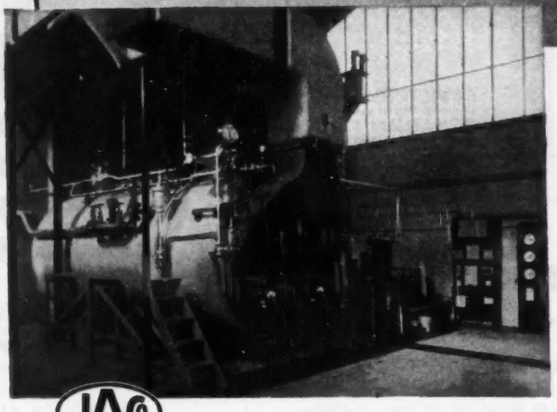

The new, revised edition of our booklet "The Choice of a Boiler" gives a concise summary of various types of shell boiler, and will be sent to responsible engineers, etc., writing on firms' letter headings.

The Joseph Adamson Dryback single tubular pass boiler consists of a cylindrical shell of lengths up to 17ft., in which the furnace flues are placed as low as possible and two nests of tubes 2¾in. or 3in. o.d. are disposed above the flues. The front and back end plates are flanged to meet the shell and the flues. The furnace sections have the usual Adamson Flanged Seam Joints. An insulated fire brick-lined combustion chamber is attached to the back end of the boiler and a smoke-box to the front end plate. Longitudinal bar stays are provided to resist the pressure on the flat surface of the end plates in the steam space.

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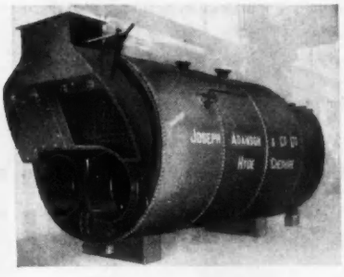

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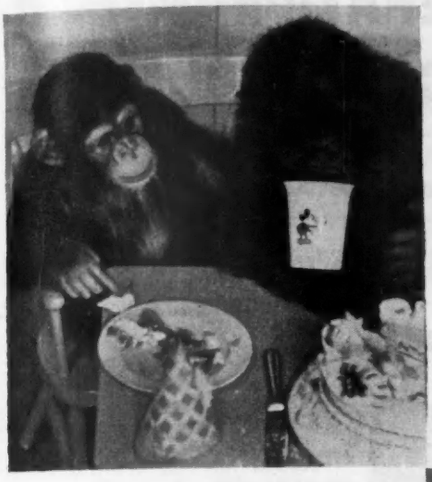

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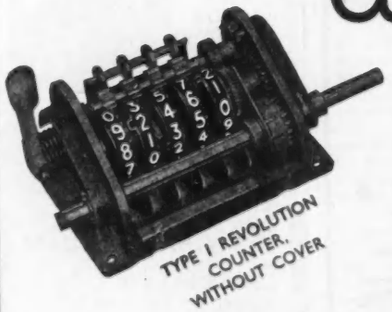

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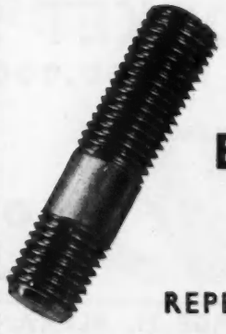

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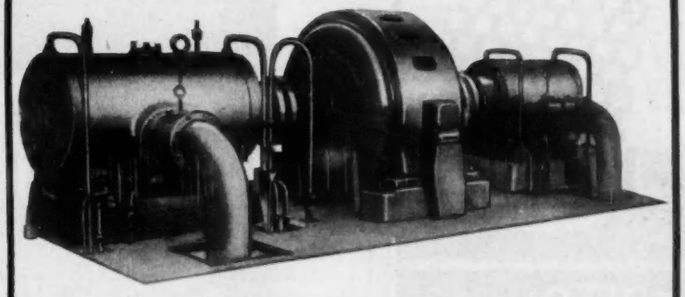

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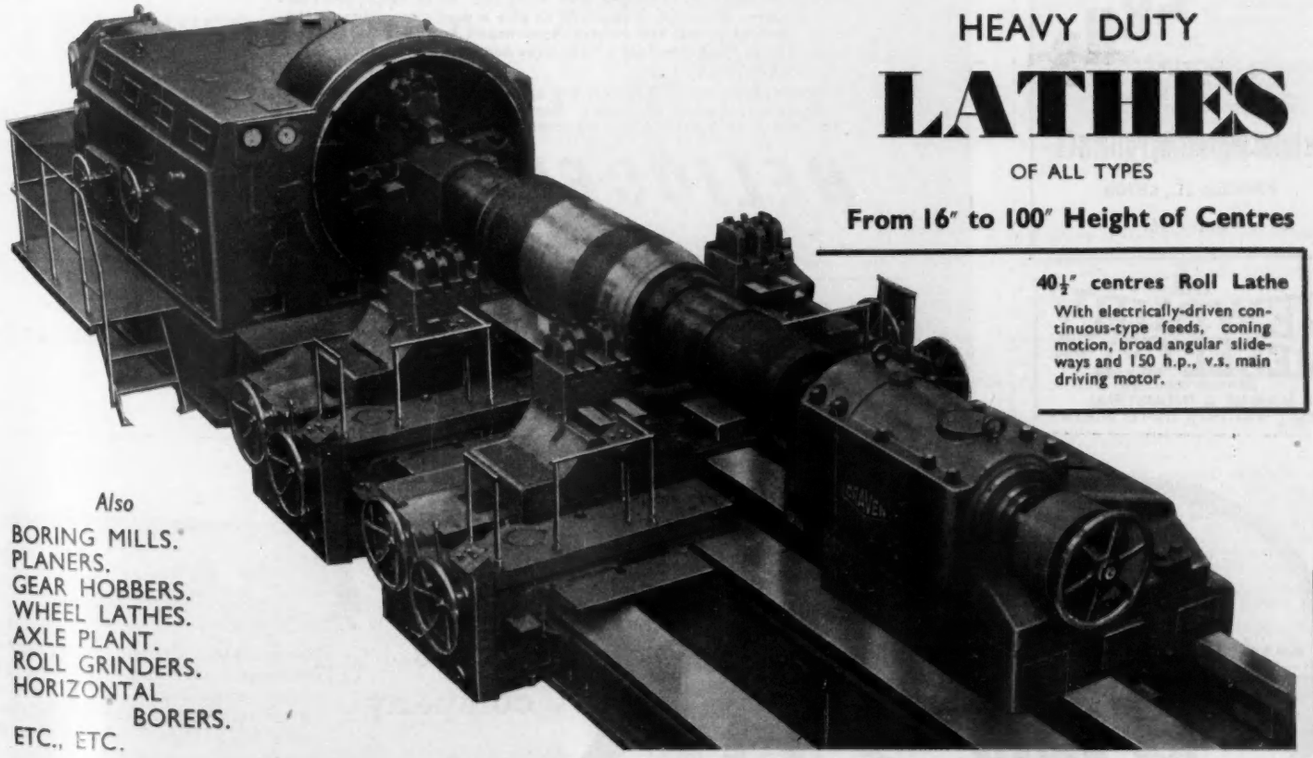

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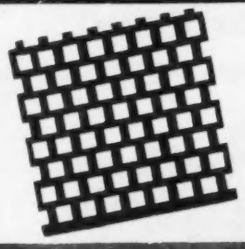
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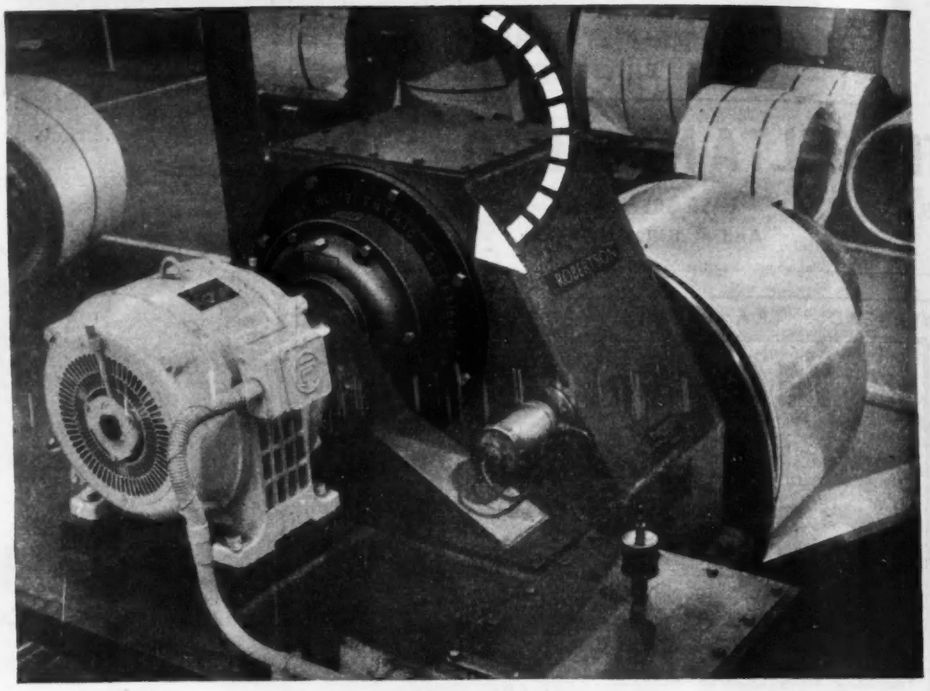
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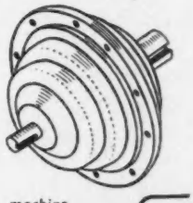
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Illustration at right shows flange mounted gear as incorporated in the above machine.
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KOLOK Positive lock Washer

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Classified Advertisements continued from Page 7

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DRAUGHTSMAN required for Engineering Dept. of Manufacturing concern. Age approx. 24-30. Educated to H.N.C. preferred. Experience in General Engineering, Plant Layout, Buildings, Factory Services, etc. Some electrical experience would be an advantage. Good man capable of working with minimum of supervision would find good conditions of employment, Canteen facilities, pension Scheme etc. Replies giving full details and salary required to MARTIN BLACK & CO. (WIRE ROPES) LTD., SPEEDWELL WORKS, COATBRIDGE. L 127

PRODUCTION ENGINEER. Applications are invited from men aged 35-45 for the position of Production Engineer with a Glasgow Firm of Structural Engineers. The vacancy offered is a senior one and carries excellent prospects. Applications should be made stating age, degrees, qualifications and past experience. Salary according to qualifications and experience but not less than £1200 per annum.—Write 1454, WM. PORTEOUS AND CO., GLASGOW. L 747

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STRUCTURAL ENGINEER required by London firm of Consultants to take charge of their steel design office. Candidates must have a comprehensive knowledge of all types of structural steelwork both designing and detailing and should preferably have had some works experience. Applicants should be Corporate Members of one of the senior professional Institutions or hold similar Degrees. The post is a permanent one and there is a Staff Pension Scheme.—Please reply in confidence to BOX NO. 389, GLOVERS ADVERTISING, LTD., 351, OXFORD STREET, W.1. G 643

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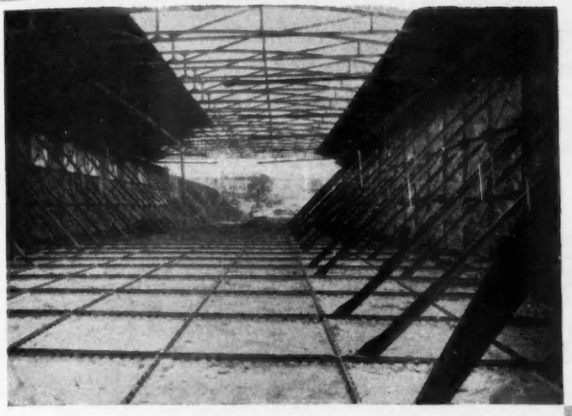
This is a Senior Company appointment and will carry a salary commensurate with ability and achievements. An excellent opportunity for a young practical engineer of energetic and inventive disposition.—BOX L 491, Offices of ENGINEERING.



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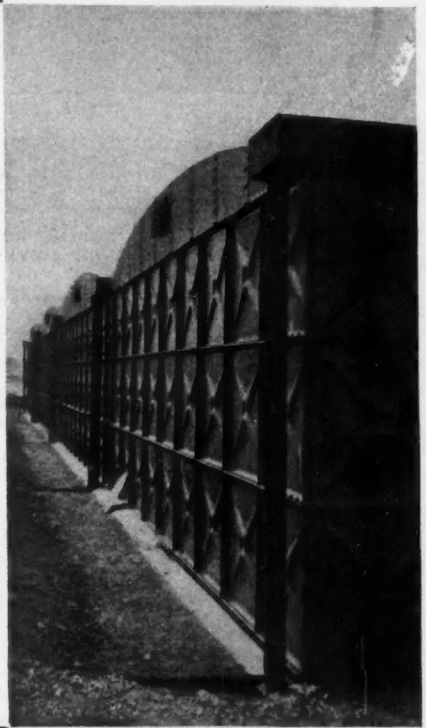

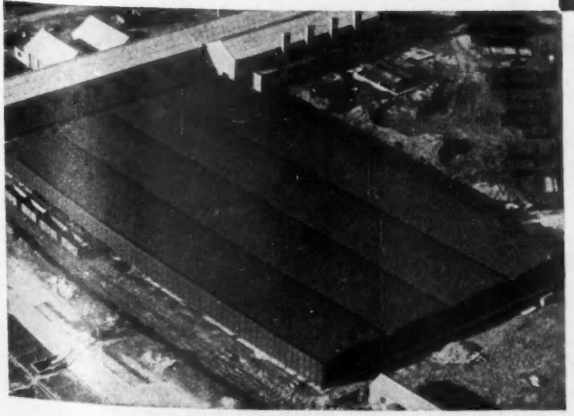

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MECHANICAL ENGINEERING ESTIMATOR.

A vacancy exists for a Mechanical Engineering Estimator—age 25 to 40. Candidates must have served a recognised engineering apprenticeship and hold a National Certificate (preferably Higher) in Mechanical Engineering. Some previous experience of estimating is essential and drawing office experience is desirable. The duties will consist of estimating costs of construction of chemical engineering projects, some of which are of novel design, and checking subsequent expenditure during erection.
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(*a*) Small I.C. Engine components.
(*b*) Fuel Injection and Hydraulic Control Mechanisms on a production basis.
Applicants should have experience in these or similar fields.
Pleasant working conditions. Generous salary commensurate with qualifications demanded. Attractive pension scheme. Comprehensive welfare facilities.
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COURTAULDS LIMITED requires a **TECHNICAL ASSISTANT** in the Central Instrument Department in Coventry. Work includes the carrying out of technical calculations, correlation and assessment of data, etc., and assisting in the preparation of instrument control schemes for a wide variety of processes. Experience in the instrument field is not an essential requirement for this position.
Men: Minimum qualification National Certificate in Engineering but Higher National very desirable.
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JOHN BOOTH & SONS (BOLTON), LTD., invite applications for the position of
MANAGER for their Branch Works in Bolton. Candidates should have had experience in the manufacture of Steel Doors and Steel Rolling Shutters, and should write stating age and experience to THE DIRECTORS, JOHN BOOTH & SONS (BOLTON), LTD. HULTON STEELWORKS, BOLTON. L 498

Classified Advertisements continued on Page 124

Leading manufacturers of container closures in the Midlands have a numbes of vacancies for ambitious **DESIGN DRAUGHTSMEN** preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation. Write in confidence with details of experience, positions held, salary required, to P.A. METAL CLOSURES LIMITED, BROMFORD LANE, WEST BROMWICH. G 627

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Design and Construction Engineers of world-wide repute in the petroleum and chemical industries invites applications from junior and senior graduate chemical and/or mechanical engineers
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PROCESS PIPING ENGINEERS.

The work consists of the preparation of piping flow diagrams both for process and utility systems. Engineers in these positions will work intimately with the process design of refinery and chemical plants and handle problems of instrumentation, pumping, gas compression, heat exchange and other unit operations. A formal training programme is arranged for new employees.

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LUNCHEON VOUCHERS.
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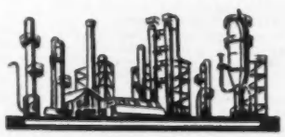
Holiday arrangements will be honoured. Interviews can be arranged to suit applicants by prior appointment by telephoning MUSeum 4010.



L 598

FERODO LIMITED, CHAPEL-EN-LE-FRITH Via Stockport, have vacancies for the following:—

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You are invited to submit full details of experience, age, qualifications and salary required to the PERSONNEL MANAGER, quoting the appropriate reference number. L 712

SALES MANAGER required by a well-established Company with an international reputation in the design and manufacture of mining plant, water turbines and special engineering projects. Applicants must have a sound training in heavy engineering coupled with first class administrative experience and be capable of negotiating contracts at the highest level. The position offers excellent prospects together with appropriate salary and superannuation.—Applications, with full details of age, education, qualifications, experience which will be dealt with in strict confidence should be addressed to BOX 197, R. ANDERSON & CO., 14, WILLIAM IV STREET, LONDON, W.C.2. L 765

BRITISH THOMSON-HOUSTON CO., LTD.

There are vacancies in the Valve Engineering Department for work connected with the engineering and development of semi-conductor devices. Those with qualifications (H.N.C. and above) in electrical engineering or physics are wanted for development projects involving transistors and rectifiers; an interest in radio would be an advantage. Qualified Mechanical Engineers (H.N.C. and above) are needed to design and develop jigs and automatic machines for device manufacture.

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are required for work in the new and rapidly expanding laboratories of Louis Newmark, Ltd., at New Addington, Surrey. The work includes the design and development of instruments and equipment for the aircraft and allied industries, and some working experience of small electromagnetic instruments is desirable. Good salary based on age and experience. Pension Scheme.—Apply in writing giving full particulars to: PERSONNEL OFFICER, LOUIS NEWMARK, LTD., PREFECT WORKS, PURLEY WAY, CROYDON. L 750

DRAUGHTSMEN
required by
THE BELMOS CO., LTD.

Mechanical Engineering Draughtsmen for Sheet Metal D.O. and Electrical Draughtsmen for Electrical D.O.

These vacancies occur at our Blantyre factory where we are expanding rapidly. Salary not less than £690 p.a. at age 25. Good working conditions in modern factory. Superannuation scheme. Canteen facilities.

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This expanding
organisation offers excellent opportunities
for advancement to men with initiative who seek an
interesting career with a really progressive firm.

SENIOR DESIGNERS, DEVELOPMENT ENGINEERS & DRAUGHTSMEN

should apply to the Technical Manager,
THE HYMATIC ENGINEERING CO., LTD.,
REDDITCH, WORCESTERSHIRE.

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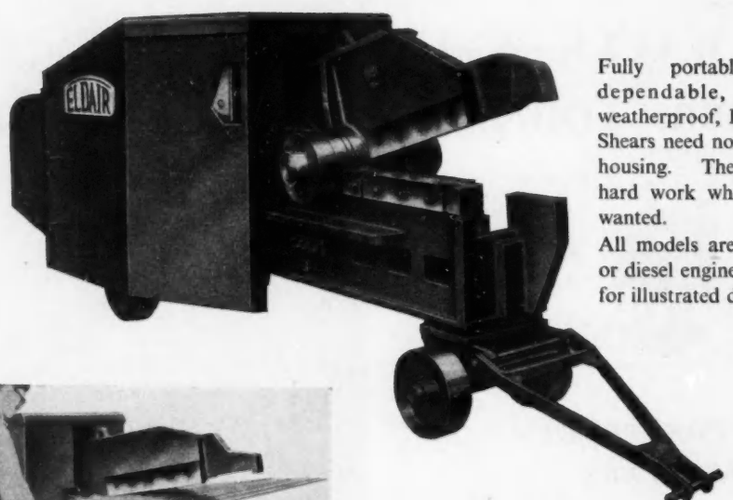
Experience is desirable in precision engineering, aircraft accessories, pneumatics or hydraulics, together with adequate technical training. L 664

ELDAIR
PORTABLE SHEARS



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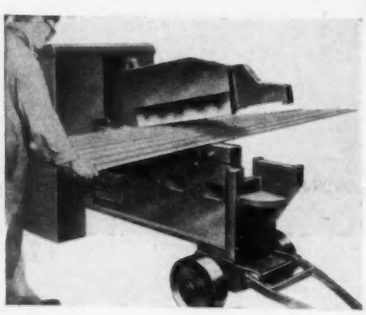

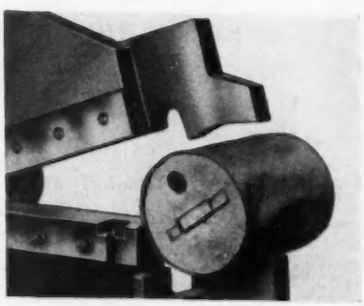

- **MODEL No. 1.**
  Cutting speed 40 strokes per minute. Blade length, 24in. Capacity in Mild Steel: ⅜in. plate, 1¾in. square, 2in. rounds, 6in. pipe. Crushes up to 12in. Weight, 4½ tons.
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  40 strokes per minute. Blade length, 30½in. Mild Steel capacity: ⅜in. plate, 1¼in. rounds, 6in. pipe. Crushes up to 15in. Weight, 3½ tons.
- **MODEL No. 0.**
  60 strokes per minute. Blade length, 12in. Capacity in Mild Steel: 1¼in. rounds, 1in. squares, 1¼in. pipe. Crushes up to 4in. pipe. Weight, 32 cwts.
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  40 strokes per minute. Blade length, 30½in. Capacity in Mild Steel: 1¼in. rounds, 1in. squares, ½in. plate. Crushes up to 10in. Weight, 2½ tons.

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THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION has a vacancy for a **RESEARCH ASSISTANT (MALE)** in the Operational Research Section. Work will be concerned with studies of works organisation, and the successful applicant will assist in the collection of data in the field, and with its analysis. Applicants should have an Ordinary National Certificate in engineering or applied physics or "A" level G.C.E. in mathematics. Starting salary up to £575 p.a. according to age, qualifications and experience. Location of work London.—Written applications only, quoting O.R.6, to the PERSONNEL OFFICER, B.I.S.R.A., 11, PARK LANE, LONDON, W.1. L 707

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Classified Advertisements continued on Page 126

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Applications are invited for several interesting positions in the RESEARCH DEPARTMENT at Birmingham. The successful applicants would be required to assist investigations in a wide variety of research projects concerned with non-ferrous metals and alloys. Candidates should possess either a degree, Higher National Certificate, or an equivalent professional qualification in either Metallurgy, Physics or Mechanical Engineering, and must have fulfilled their National Service obligations.

These positions offer a generous starting salary, dependent upon age, qualifications and experience, and there is adequate scope for progressive remuneration. The Company operates both Pension and Profit Sharing Schemes and married men will receive a reasonable refund of removal (including travel) expenses.

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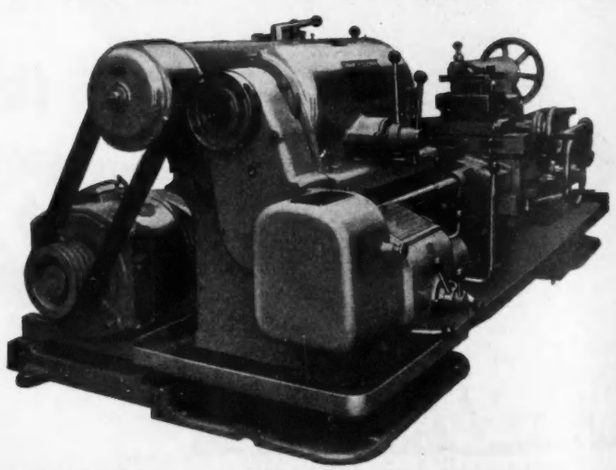

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Gas fired. Bath size 8 ft. by 3 ft. by 3 ft. Fully automatic control. Two rinse tanks 8 ft. by 3 ft. by 3 ft., with Coil and Thermostat. Cost £2500.
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All sizes of machine from ⅜ in. to 1 in. mild steel cutting capacity.
Rotary blade-beam action with fast independent return system.
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Classified Advertisements continued on Page 128

SOAG

REBUILT AND GUARANTEED HEAVY DUTY SLOTTERS AVAILABLE IMMEDIATELY

★ All late type machines, motorised for 400/3/50 supply.

We shall be pleased to quote against your requirements. Send us details.

BUTLER 8in. High Production, motor drive, with automatic and hand long., cross and rotary table movements, max. length of stroke 8in., table dia. 20in., dia. admitted 24in., ram face to frame 12in., table traverse long. and cross 15½in., 4 ram speeds, 31-90 strokes/min., h.p. of motor 5.

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BUTLER 28in. High Production, with electric feed unit and power traverse, enabling control of the machine to be made from the operator's push-button station, ram balanced by counterweight max./min. stroke of ram 28/10in., dia. admitted 5ft. 9in., gap 3ft. 9in., table traverse long. or cross 3ft. 6in., table dia. 5ft., h.p. of main motor 20.
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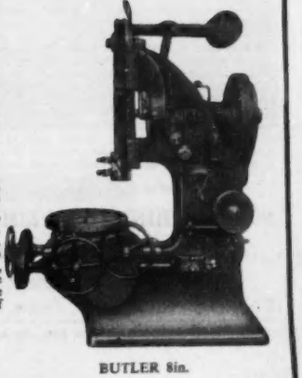

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NEW WOODHOUSE & MITCHELL 70 JUNIOR, 7 in. S.S. & S.C. Lathe; elec. equip. for 400-440/3/50.

NEW WOODHOUSE & MITCHELL 85 Heavy Duty 8½ in. Centre Lathe; 12 spindle speeds, 21-945 r.p.m.; motorised 3-phase supply.

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Remember — Ward's might have it!
G 60

PENSOTTI 5ft. Motor Driven
High Speed
VERTICAL BORING MILLS

with taper turning and screw cutting attachment. Max. swing 62 in. dia. Rapid power traverses. 16 speeds from 4 to 145 r.p.m. Motor 28 h.p. Approx. weight 10 tons. 1951-2 machines in excellent condition.

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AVAILABLE FROM STOCK.

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Full details on request to:

SOAG MACHINE TOOLS LIMITED,
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'Phone: RELiance 3373.
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Edwards

RHODES GEARED BENDING ROLLER. Pinch roll type. Belt drive. Capacity 49½ in. by 16 s.w.g. Dia. of rolls 3 in. Weight about 8 cwt.

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GACK OPEN ENDED OVERCRANK GUILLOTINE. On stand. Motorised 380/3/50. Automatic hold-down. Capacity 16⅝ in. by 14 s.w.g. Gap depth 3 in. Weight about 12¼ cwt.

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PATENTS.

THE PROPRIETORS OF BRITISH PATENT NO. 552465, for "IMPROVEMENTS IN MACHINES FOR CASTING METALS," desire to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder.—Further particulars may be obtained from MARKS & CLERK, 57 & 58, LINCOLN'S INN FIELDS, LONDON, W.C.2. L 725

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ALBION WORKS, SHEFFIELD
G 556

COMPANY MEETING

THE BRITISH PETROLEUM COMPANY.

SUBSTANTIAL PROGRESS IN ALL ASPECTS OF BP GROUP'S OPERATIONS.

FULL PART IN MEETING WORLD'S EXPANDING DEMAND.

MR. B. R. JACKSON ON THE TASK AHEAD.

The forty-seventh annual general meeting of The British Petroleum Company, Ltd., will be held on June 7 at Britannic House, Finsbury Circus, London, E.C.

The following is an extract from the circulated statement of the Chairman, Mr. B. R. Jackson :—

In addressing you for the first time as Chairman, I must begin by paying high tribute to the great services to the Company of my predecessor, Lord Strathalmond. His decision to retire on 31st March last ended a period of thirty-three years as a Director. The B.P. Group's remarkable expansion over that period, as instanced by the growth of its sales from 3,000,000 tons in 1923 to 48,000,000 tons last year, testifies to the outstanding ability, foresight and leadership of Lord Strathalmond in the conduct of your affairs.

During 1955 substantial progress was made in all aspects of the B.P. Group's operations. Our total sales increased by 15 per cent., crude oil production by 25 per cent., and refining throughput by 23 per cent., while exploration and marketing operations were further diversified and extended. The Company thus played a full part in meeting the free world's expanding demand for petroleum, which increased by 11 per cent. in 1955, continuing the post-war trend which has resulted in a doubling of world consumption of oil products in the last ten years.

The roots of this strong demand lie not only in the growth of industrial activity and improving standards of living; they also, in the Eastern Hemisphere, lie in the more limited capacity for increasing output of the other major sources of energy, especially coal. There is every indication that this combination of factors will maintain the post-war rate of expansion in world petroleum consumption until nuclear power becomes available to supplement world energy resources on a substantial scale. Thus, in the next ten years the world petroleum industry may well be again called upon to double its present output. The rate of expansion can be expected to continue as now, to be greater in the Eastern Hemisphere, where this Company mainly operates; and the Middle East oil-producing territories, in which we have so substantial a position, are expected to contribute an increasingly large proportion of the world's requirements.

The discovery, production, refining, transportation and distribution to the consumer of the oil supplies needed to meet such a future demand can only be achieved by large-scale capital expenditure on the facilities necessary for each of these operations. The oil industry generally, and the B.P. Group as one of its major components, will have to provide for the greater part of this expenditure from its own resources. If the industry is to maintain its record of meeting all consumers' needs, the performance of the task which lies ahead of it will require both adequate economic price-levels and the continued ploughing back of a high proportion of earnings to finance future growth.

THE ACCOUNTS.

The Consolidated trading profit and other income for 1955 before providing for Depreciation and Overseas Taxation was £139,817,943, compared with a corresponding figure of £118,228,792 for 1954.

Depreciation totalled £22,143,401 compared with £30,406,091 for 1954. The reduction of £8,262,690 is mainly under the heading of Fixed Assets on which expenditure in 1955 was considerably lower than in 1954. The reduced capital expenditure marks the virtual completion of the recent heavy programme of refinery expansion and tanker construction, but as indicated by the figures totalling £97,200,000 mentioned in the Accounts, capital expenditure is certain to be heavy if the Company is to keep pace with the frequently changing improvements and expansion of the oil industry.

The 1955 figure of Overseas Taxation of £62,691,602 compares with £42,879,851 for 1954, the increase in the main being due to our larger offtake of oil from the countries concerned. Provision for United Kingdom taxation, after double taxation relief, amounts to £8,697,875.

The amount available for Reserves and Dividends is £46,189,539 compared with £17,043,404 for 1954. In view of anticipated requirements for future capital expenditure, your Directors have placed £28,500,000 to General Revenue Reserve and have recommended a final dividend on the Ordinary Stock of two shillings per £1 stock unit free of income tax, making a total for the year of three shillings per £1 stock unit free of income tax. The total now standing to the credit of General Revenue Reserve is £75,000,000.

The total capital expenditure of the Group during 1955 was approximately £43,000,000.

PRODUCTION.

Our total crude oil production in 1955 was 46,000,000 tons, over 9,000,000 tons more than in 1954, the increase being mainly due to larger production in Iran and Kuwait.

In the United Kingdom, although production from the older fields decreased to about 54,000 tons from 59,000 in 1954, we were encouraged by the new production discovered during the year at Egmanton, six miles north of the Eakring field. Six wells have been completed in this new field and are now yielding a production more than sufficient to offset the decline from the older fields.

The Chairman then reviewed the production and exploration operations in the various overseas territories in which the Group had interests.

REFINING.

Our total refinery throughput in 1955 was 29,500,000 tons, 5,500,000 tons more than in 1954. This increase was mainly due to 1955 being the first complete operating year of Aden refinery, and the first operating year of Kwinana refinery in Western Australia, commissioned in February, 1955; also to our share of processing at Abadan during its first complete year's operation under the Consortium agreement of October, 1954.

In Great Britain, the total throughput of our Kent, Llandarcy, and Grangemouth refineries decreased by some 2,000,000 tons to 8,500,000 tons; this being due to the major increases in offtake from Aden, Kwinana and Abadan replacing the uneconomically routed products which had, during the last four years, to be drawn from the United Kingdom refineries to assist in the supply of our Eastern markets.

At Kent, where lubricating oil production at 84,000 tons was more than double the 1954 figure, crude distillation capacity, now 4,600,000 tons, is to be increased to over 7,000,000 tons. New plant for the manufacture of aviation spirit and improved diesel fuels is to be installed, and a further catalytic reformer to increase production of high grade motor spirit.

At the Grangemouth plant of British Hydrocarbon Chemicals, Ltd., production of industrial alcohols reached a new high level.

The statement then referred to the refinery operations in France, Germany, Belgium, Italy, Aden, Kuwait, Australia and Iran, and continued:—

SEA TRANSPORT.

The British Tanker Company's fleet now consists of 144 ships totalling 2,018,000 deadweight tons, and we have also about 2,500,000 tons of tanker shipping on charter. There are now 41 ships totalling 1,225,500 deadweight tons under construction or on order for the British Tanker Company. The estimated cost of this building programme exceeds £80 million.

DISTRIBUTION AND SALES.

In 1955 world consumption of petroleum outside the Soviet sphere was approximately 700 million tons, an increase of nearly 70 million tons or about 11 per cent. In the Eastern Hemisphere, where our main interests lie, consumption expanded by about 15 per cent. (which compares with an average of nine per cent. during the previous three years), the main contribution being a 17 per cent. increase in Western Europe, including the United Kingdom; this remarkable gain was due to a combination of generally high industrial activity with the inability of coal and other fuel sources to satisfy the demand for energy needed to maintain such activity.

The B.P. Group's sales of crude oil and refined products in 1955 attained the record level of 48 million tons, an increase of more than 6 million tons or 15 per cent. over the 1954 total.

In the United Kingdom, total demand for petroleum products expanded by nearly 10 per cent. in 1955. In the case of fuel oil the increase was over 20 per cent., a plain indication of its rapidly expanding contribution to the energy needs of this country.

We have continued to strengthen and expand our direct marketing outlets; the capital expenditure involved is well justified by the increased assurance which it gives us of continuity of offtake.

The international coverage of P.B. Aviation Service and our sales of aviation fuels are steadily expanding.

The B.P. International Oil Bunkering Service, now in its thirty-sixth year of operation, is established at more than 160 ports on world shipping trade routes.

Sales of our lubricants have increased very satisfactorily. B.P. Energol brands have been introduced successfully in the following new areas: Portugal, Spanish Morocco, Tangier, Gibraltar, British and French West Africa, Iceland and Madeira. Our new motor oil, B.P. Energol Visco-Static, has established itself in a foremost position as a multigrade oil in the United Kingdom, on the Continent and in Australia. Good progress also continues to be made in the international marine oil market.

There is still no sign of any reduction in the heavy burden of taxation levied on motor fuel which is holding back the natural increase in consumption of motor spirit throughout most of the area in which we market. This position handicaps the oil industry, despite its great flexibility, in its effort to provide the quantities of fuel oil required to meet the rising demand for energy.

The work of our Research and Development Department has been further extended during the year, with particular emphasis on ensuring the highest quality of all our products. L 688

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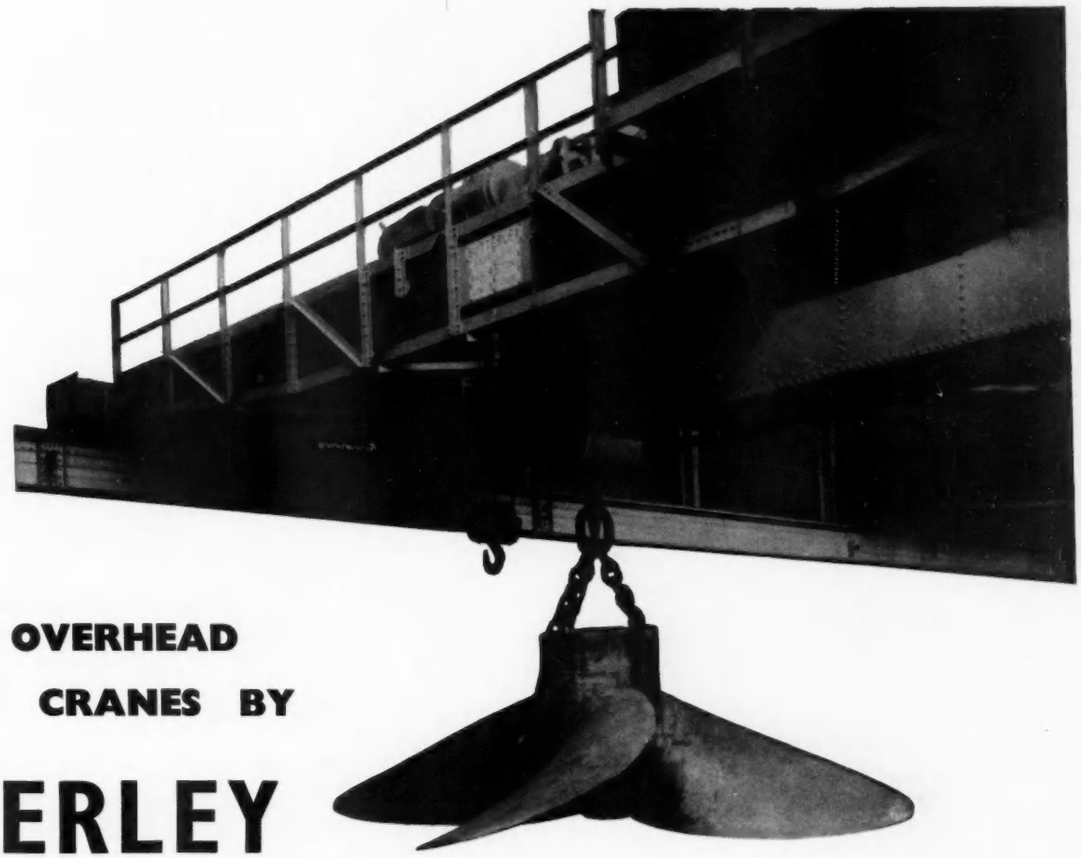

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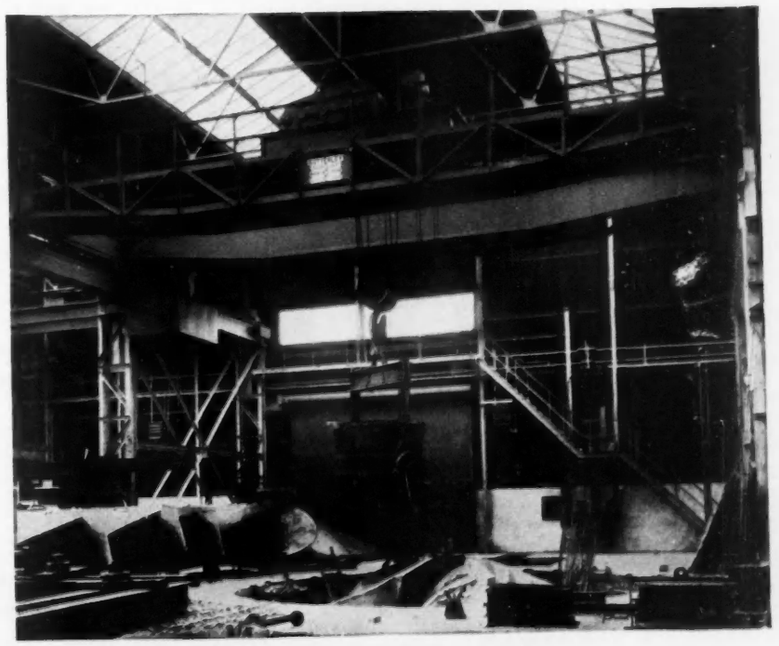

Since these photographs were taken, orders have been received for three more cranes of similar capacity.

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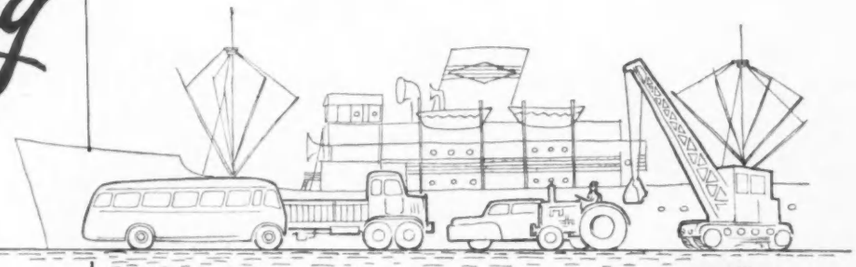

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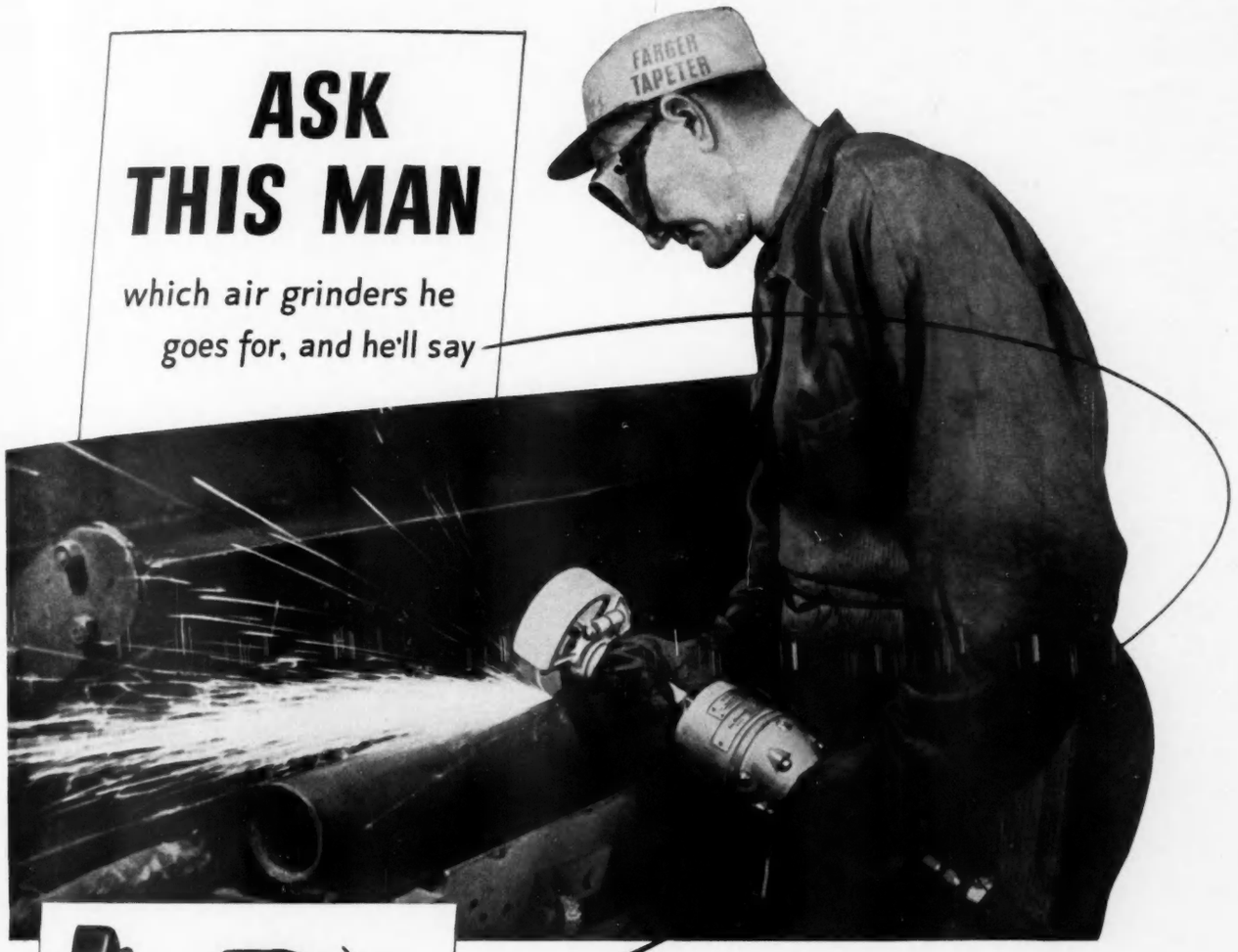

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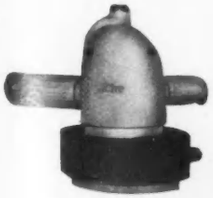

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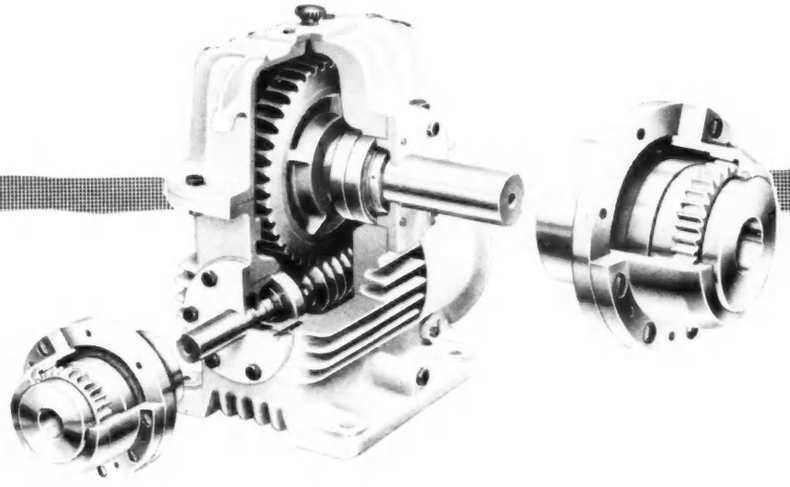

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